PRELIMINARY—NASA APPROVAL PENDING

DRA

Space Shuttle Program

MSC-03315

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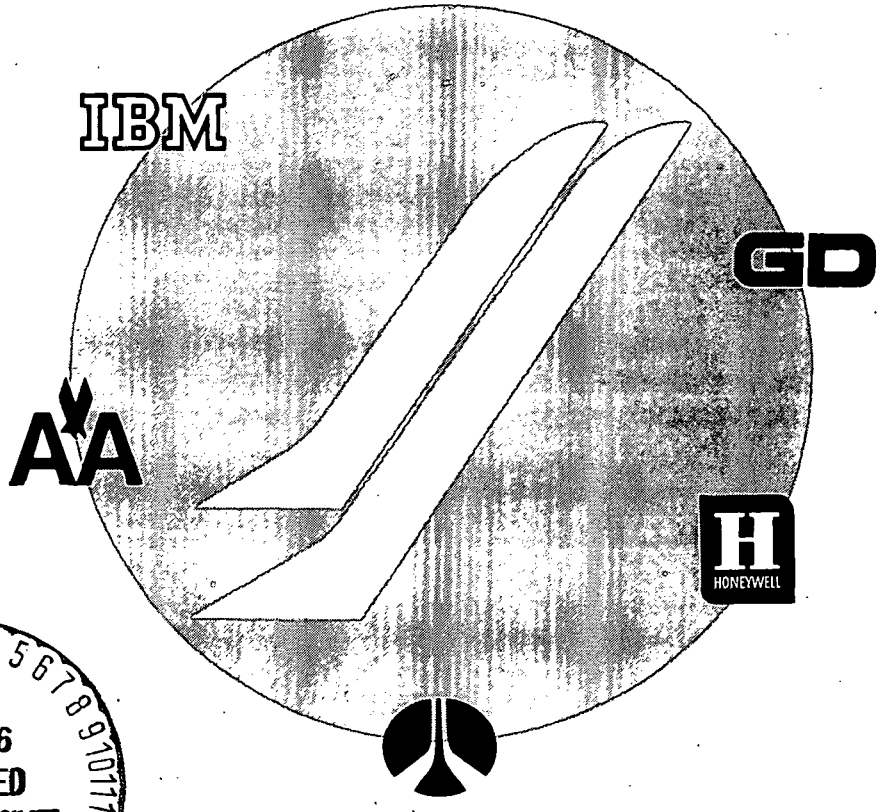

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Specification No. 76Z0500

Booster Vehicle Prime Item Specification

Part 1

SPACE SHUTTLE SYSTEM

DRL M010, DRL Line Item 21
DRD CM007M
25 June 1971

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Space Division • North American Rockwell 12214 Lakewood Boulevard, Downey, California 90241

Preliminary–NASA Approval Pending

(MSC-03315)

25 June 1971

SPECIFICATION NO. 76Z0500
BOOSTER VEHICLE PRIME ITEM SPECIFICATION

Part I
SPACE SHUTTLE SYSTEM

Approved by

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Vice President and Director
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Vice President and General Manager
Space Shuttle Program

Contract NAS9-10960
DRL M010, DRL Item 21
DRD CM007M

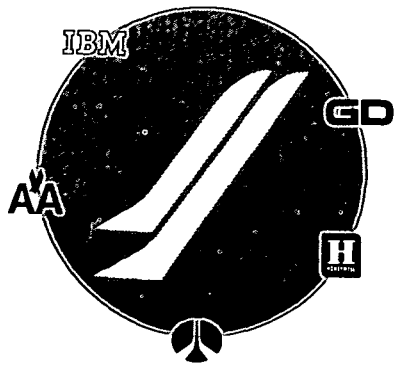

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TABLE OF CONTENTS

Paragraph No.		Page
1	SCOPE	1
1.1	Content	1
1.2	Organization of This Document	1
2	APPLICABLE DOCUMENTS	3
3	REQUIREMENTS	9
3.1	Item Definition	9
3.1.1	Item Diagrams	9
3.1.2	Interface Definition	9
3.1.2.1	Subsystem Interfaces	9
3.1.3	Major Component List	20
3.1.4	Government-Furnished Property List	20
3.1.5	Government-Loaned Property List	20
3.2	Characteristics	21
3.2.1	Performance	21
3.2.1.1	Perform Mission	21
3.2.1.1.1	Mated Ascent	21
3.2.1.1.1.1	Performance Characteristics (Functions)	21
3.2.1.1.1.1.1	Response to External Influences	21
3.2.1.1.1.1.2	Propellant Rate and Control.	21
3.2.1.1.1.1.3	Communication Rates	26
3.2.1.1.2	Booster-Orbiter Staging	26
3.2.1.1.2.1	Performance Characteristics	26
3.2.1.1.2.1.1	Response Rate (Speed of Response)	26
3.2.1.1.2.1.2	Propellant Rate and Control	26
3.2.1.1.2.1.3	Communication Rates	26
3.2.1.1.3	Entry and Transition Flight Phase	26
3.2.1.1.3.1	Flight Characteristics	26
3.2.1.1.3.1.1	Center of Gravity Location	26
3.2.1.1.3.1.2	Control	26
3.2.1.1.3.1.3	Communication Rates	31
3.2.1.1.4	Cruise Back Flight	31
3.2.1.1.4.1	Communication Rates	31
3.2.1.1.5	Descent	31
3.2.1.1.5.1	Communication Rates	31
3.2.1.1.6	Approach	34
3.2.1.1.6.1	Communication Rates	34

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TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.2.1.1.7	Landing	34
3.2.1.1.7.1	Landing Conditions	34
3.2.1.1.7.2	Communication Rates	34
3.2.1.1.8	Waveoff/Go-Around	34
3.2.1.1.8.1	Communication Rates	34
3.2.1.2	Ferry	34
3.2.1.2.1	Takeoff	34
3.2.1.2.1.1	Communication Rates	34
3.2.1.2.2	Climb to Cruise Altitude	34
3.2.1.2.2.1	Communication Rates	34
3.2.1.2.3	Ferry Cruise Range	35
3.2.1.3	Abort	35
3.2.1.3.1	Prelaunch	35
3.2.1.3.2	Mated Ascent	35
3.2.1.3.2.1	Early Separation	35
3.2.1.3.2.2	Post Separation	35
3.2.1.4	Taxiing	35
3.2.1.5	Useful Life	35
3.2.1.5.1	Utilization Rate	35
3.2.1.6	Prelaunch Support Performance	35
3.2.1.7	Launch	36
3.2.1.8	Support and Post Launch Performance	36
3.2.1.9	Purging Time	36
3.2.2	Physical Characteristics	37
3.2.2.1	Engines	37
3.2.2.2	Dimension and Cube Limitations	37
3.2.2.3	Weight	37
3.2.2.4	Strength and Rigidity	37
3.2.2.4.1	Structural Criteria	37
3.2.2.4.2	Design Loading	37
3.2.2.4.3	Maneuvering Flight Factors	37
3.2.2.4.4	Landing and Ground Handling	37
3.2.2.4.5	Flutter, Divergence and Aerostability	45
3.2.2.4.6	Windshield Design	45
3.2.2.5	Safety	45
3.2.2.5.1	Cockpit Station	45
3.2.2.5.2	Visibility	45
3.2.2.5.3	Cockpit Ingress/Egress	45
3.2.2.5.4	Emergency Escape	45

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.2.2.5.5	Propellant Depletion	45
3.2.2.5.5.1	Purge Safing	45
3.2.2.5.6	Venting Provisions	45
3.2.2.6	Maintenance Access	47
3.2.2.7	Storage	47
3.2.2.8	Jacking, Handling, and Mooring Provisions	47
3.2.2.8.1	Jacking	47
3.2.2.8.2	Handling	47
3.2.2.8.3	Mooring	47
3.2.2.9	Holddown Provisions	47
3.2.3	Reliability	48
3.2.3.1	Reliability Requirements	48
3.2.3.2	Reliability Analysis Assumptions	48
3.2.3.3	Success/Failure Criteria	48
3.2.4	Maintainability	48
3.2.4.1	Maintainability Requirements	48
3.2.4.1.1	Accessibility for Maintenance	48
3.2.4.1.2	Access Openings	48
3.2.4.1.3	Maintainability Design Features	49
3.2.4.2	Maintenance and Repair Cycles	49
3.2.4.3	Unscheduled Maintenance	49
3.2.4.4	Scheduled and Periodic Maintenance	49
3.2.4.5	Major Overhaul	49
3.2.4.5.1	Line Replaceable Units	49
3.2.5	Environmental Conditions	50
3.2.5.1	Natural Environments	50
3.2.5.2	Induced Environments	50
3.2.5.2.1	Aerothermodynamics (External)	50
3.2.6	Transportability	50
3.3	Design and Construction	60
3.3.1	Materials, Parts and Processes	60
3.3.1.1	Cleanliness and Contamination Limits	60
3.3.2	Electromagnetic Compatability	60
3.3.3	Nameplates and Product Marking	60
3.3.3.1	Lot Marking	60
3.3.4	Workmanship	60
3.3.5	Interchangeability	62
3.3.6	Safety	62
3.3.7	Human Performance/Human Engineering	62

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.3.8	Design Disciplines	62
3.3.8.1	Electrical	62
3.3.8.2	Electronic	64
3.3.8.3	Hydraulic System	64
3.3.8.4	Pneumatic System	64
3.3.8.5	Flight Control	64
3.3.8.5.1	Control System	64
3.3.8.5.2	Stabilization System	64
3.3.8.5.3	Stability	64
3.3.8.6	Environmental Control	64
3.3.8.7	Displays and Controls	65
3.3.8.8	Flight Personnel Provisions	65
3.3.8.9	Landing System	65
3.3.8.10	Thermal Protection System	65
3.3.8.11	Bonding Protection	65
3.3.8.12	Maintainability	65
3.3.8.13	Flying Qualities	65
3.4	Documentation	66
3.4.1	Documents for Design Review and Approval	66
3.5	Logistics	66
3.5.1	Maintenance	66
3.5.1.1	Maintenance and Repair Cycles	66
3.5.1.2	Accessibility for Maintenance	66
3.5.1.3	Replacement and Repair	66
3.5.2	Supply	66
3.5.3	Facilities and Facility Equipment	66
3.6	Personnel and Training	67
3.6.1	Personnel	67
3.6.1.1	Operational Personnel	67
3.6.1.1.1	Flight Personnel	67
3.6.1.1.2	Launch and Recovery Personnel	67
3.6.1.2	System Control Personnel	67
3.6.1.3	Maintenance Personnel	67
3.6.2	Training	67
3.6.2.1	Maintenance Crew Training	67
3.7	Major Component Characteristics	68
3.7.1	Body Structure	68
3.7.1.1	Interfaces	68
3.7.1.2	Performance	70

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.7.1.2.1	Conditions for Performance	70
3.7.1.2.2	Control Equations	70
3.7.1.2.3	Loading - Unloading Shocks	70
3.7.1.2.4	Structural Limit Loads	70
3.7.1.2.5	Maximum Bending Load	70
3.7.1.2.6	Longitudinal Oscillation Loads	70
3.7.1.2.7	Maximum Axial Loads	70
3.7.1.2.8	Orbiter Mating and Separation	71
3.7.1.2.8.1	Separation	71
3.7.1.2.8.2	Mating	71
3.7.1.3	Physical Characteristics	71
3.7.1.3.1	General Description	71
3.7.1.3.2	Retraction Provisions	71
3.7.2	Aerodynamic Surfaces	72
3.7.2.1	Interfaces	72
3.7.2.2	Performance	72
3.7.2.2.1	Conditions for Performance	72
3.7.2.2.2	Control Equations	72
3.7.2.2.3	Structural Limit Loads.	72
3.7.2.2.4	Separation Loads	72
3.7.2.3	Physical Characteristics	72
3.7.3	Thermal Protection.	74
3.7.3.1	Interfaces	74
3.7.3.2	Performance	74
3.7.3.2.1	Conditions for Performance	74
3.7.3.2.2	Control Equations	74
3.7.3.2.3	Reuse	74
3.7.3.3	Physical Characteristics	74
3.7.4	Landing System	74
3.7.3.1	Interfaces	74
3.7.4.2	Performance Characteristics	77
3.7.4.2.1	Conditions for Performance	77
3.7.4.2.2	Loading	77
3.7.4.2.3	Rate for Extension and Lockdown	77
3.7.4.2.4	Rate of Retraction and Locking	77
3.7.4.2.5	Braking.	77
3.7.4.3	Physical Characteristics	77
3.7.5	Main Propulsion	77
3.7.5.1	Interfaces	77
3.7.5.2	Performance	79

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.7.5.2.1	Conditions for Performance	79
3.7.5.2.2	Control Equations	80
3.7.5.2.3	Flow Rates	80
3.7.5.2.4	Propellant Gaging	80
3.7.5.2.5	Tank Pressurization	80
3.7.5.3	Physical Characteristics	80
3.7.6	Attitude Control Propulsion	84
3.7.6.1	Interfaces	84
3.7.6.2	Performance	84
3.7.6.2.1	Conditions for Performance	84
3.7.6.2.2	Thrust	84
3.7.6.2.3	Propellant Distribution	84
3.7.6.3	Physical Characteristics	84
3.7.7	Air-breathing Propulsion	87
3.7.7.1	Interfaces	87
3.7.7.2	Performance	87
3.7.7.2.1	Conditions for Performance	87
3.7.7.2.2	Thrust Levels	87
3.7.7.2.3	Noise and Vibration Output	87
3.7.7.2.4	Temperature Detection	89
3.7.7.2.5	Engine Deployment Time	89
3.7.7.2.6	Propellant Loading Rates	89
3.7.7.3	Physical Characteristics	89
3.7.8	Guidance, Navigation, and Control	90
3.7.8.1	Interfaces	90
3.7.8.1.1	Checkout and Fault Isolation	92
3.7.8.2	Performance	92
3.7.8.2.1	Conditions for Performance	92
3.7.8.2.2	Control Equations	92
3.7.8.2.3	Inertial Measurement Unit Alignment	92
3.7.8.2.4	Engine Alignment	92
3.7.8.2.5	Inertial Measurement Unit Outputs (IMU)	92
3.7.8.2.6	Body Bending Suppression	93
3.7.8.2.7	Aerodynamic Load Relief	93
3.7.8.2.8	Trajectory	93
3.7.8.2.9	Separation State Vector	93
3.7.8.2.10	State Vector Update	94
3.7.8.2.11	Non-Atmospheric Automatic Attitude Control	94
3.7.8.2.12	Non-Atmospheric Manual Attitude Control	94

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.7.8.2.13	Aerodynamic Automatic Attitude Control	94
3.7.8.2.14	Atmospheric Manual Attitude Control	94
3.7.8.2.15	Hypersonic Stability and Control	95
3.7.8.2.16	Subsonic Stability and Control	95
3.7.8.2.17	Air Data Sensing	95
3.7.8.2.18	Computed Glideslope Intercept	95
3.7.8.2.19	Handling (Aerodynamic)	95
3.7.8.2.20	Booster Landing	95
3.7.8.2.20.1	Computed Glideslope Tracking	96
3.7.8.2.20.2	Flare	96
3.7.8.2.20.3	Rolling, Braking and Steering	96
3.7.8.2.21	Ferry Flight	96
3.7.9	Data and Control Management	97
3.7.9.1	Interfaces	98
3.7.9.1.1	Standard Interface with all Subsystems	98
3.7.9.1.2	Special Interfaces	101
3.7.9.2	Performance	101
3.7.9.2.1	Conditions for Performance	101
3.7.9.2.2	Central Processor Unit	101
3.7.9.2.2.1	Computing Rates	101
3.7.9.2.2.2	Program Load	101
3.7.9.2.2.3	Addressing	101
3.7.9.2.2.4	Clock	101
3.7.9.2.3	Main Storage Unit	101
3.7.9.2.3.1	Addressing	102
3.7.9.2.4	Input/Output Unit	102
3.7.9.2.4.1	Parity and Checks	102
3.7.9.2.4.2	Serial Channels	102
3.7.9.2.5	Mass Memory Unit	102
3.7.9.2.5.1	Readout	103
3.7.9.2.6	Digital Data Bus	103
3.7.9.2.7	Fault Tolerance	103
3.7.10	Displays and Controls	104
3.7.10.1	Interfaces	104
3.7.10.2	Performance	106
3.7.10.2.1	Conditions for Performance	106
3.7.10.2.2	Multiformat Cathode Ray Tube (CRT) Displays	106
3.7.10.2.3	Alphanumeric Displays	106
3.7.10.2.4	Time Readout Displays	107

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.7.10.2.5	Caution and Warning System	107
3.7.10.2.6	Control/Display Panels	107
3.7.10.3	Physical Characteristics	107
3.7.10.3.1	CRT Displays	107
3.7.10.3.2	Alphanumeric Displays	107
3.7.10.3.3	Caution and Warning	108
3.7.10.3.4	Manual Flight Controls	108
3.7.11	Communications	109
3.7.11.1	Interfaces	109
3.7.11.1.1	Standard ACT/Select Buffer Interface	111
3.7.11.2	Performance	111
3.7.11.2.1	Conditions for Performance	111
3.7.11.2.2	Mated Operations	111
3.7.11.2.3	Communication After Separation	112
3.7.11.2.4	Booster to Air Traffic Control (ATC) Network	112
3.7.11.2.5	Booster to Ground Transponder	112
3.7.11.2.6	Landing Aid	112
3.7.11.2.7	Flight Log Recorder and Recovery Beacon	113
3.7.12	Auxiliary Power Unit	114
3.7.12.1	Interfaces	114
3.7.12.2	Performance	114
3.7.12.2.1	Conditions for Performance	114
3.7.12.2.2	Power Demand	114
3.7.12.2.3	Control Equations	114
3.7.12.2.4	Control of Performance	114
3.7.12.3	Physical Characteristics	115
3.7.12.3.1	Self-Cooling Features	115
3.7.13	Hydraulic Power Generation Distribution and Control	116
3.7.13.1	Interfaces	116
3.7.13.2	Performance Characteristics	116
3.7.13.2.1	Conditions for Performance	116
3.7.13.2.2	Actuator Loads and Rate (Aerodynamic Surfaces)	116
3.7.13.2.3	Actuator Loads and Rates (Landing Gear)	116
3.7.13.2.4	System Flush and Refill	118
3.7.13.2.5	Actuation Loads and Rates (Airbreathing Engines)	118
3.7.13.3	Physical Characteristics	118
3.7.13.3.1	Reservoir	118
3.7.13.3.2	Fill and Bleed Provisions	118
3.7.13.3.3	System Fluids	118
3.7.13.3.4	Operations and Leakage	118

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.7.14	Electric Power Generation, Distribution and Control (PGDC)	120
3.7.14.1	Interfaces	120
3.7.14.1.1	APU Subsystem	122
3.7.14.1.1.1	Coolant	122
3.7.14.1.1.2	Synchronizing Signals	122
3.7.14.1.2	Utilization Subsystems	122
3.7.14.1.2.1	Remote Power Controller Interface	122
3.7.14.1.2.2	Data and Control Management (DCM) Interface	123
3.7.14.1.2.3	Displays and Controls (D&C) Interface	123
3.7.14.1.2.4	Environmental Control and Life Support Interface	124
3.7.14.1.3	Structure Interface	124
3.7.14.1.4	Ground Support Equipment (GSE) Interface	124
3.7.14.2	Performance Characteristics	124
3.7.14.2.1	Conditions for Performance	124
3.7.14.2.2	Power Generation	124
3.7.14.2.2.1	Ac Power Characteristics	125
3.7.14.2.2.2	Dc Power Characteristics	125
3.7.14.2.3	Power Output	125
3.7.14.3	Physical Characteristics	125
3.7.14.3.1	Power Distribution and Control	125
3.7.14.3.1.1	Ac Distribution and Control	125
3.7.14.3.1.2	Dc Distribution and Control	128
3.7.14.3.2	Lighting	128
3.7.15	Environmental Control and Life Support	129
3.7.15.1	Interfaces	129
3.7.15.2	Performance Characteristics	129
3.7.15.2.1	Conditions for Performance	129
3.7.15.2.2	Atmospheric Output	129
3.7.15.2.3	Heat Removal	129
3.7.15.2.4	Emergency Oxygen Output	131
3.7.15.2.5	Heat Supply	131
3.7.15.2.6	Control of Performance	131
3.7.15.2.7	Check Out Tests	131
3.7.15.2.8	Purging	131
3.7.15.2.9	Pressure Control	131
3.7.15.2.10	Fire Protection and Extinguishing	131
3.7.15.2.11	Visibility Enhancement	131
3.7.15.2.12	Air Distribution	131
3.7.15.2.13	Sanitary Relief	132

TABLE OF CONTENTS, Contd

Paragraph No.		Page
3.7.15.3	Physical Characteristics	132
3.7.15.3.1	Inert Gas Provisions	132
3.7.16	Flight Personnel Provisions	132
3.7.16.1	Interfaces	132
3.7.16.2	Performance Characteristics	133
3.7.16.2.1	Conditions for Performance	133
3.7.16.2.2	Restraint of Personnel	133
3.7.16.2.3	Acceleration Protection of Personnel	133
3.7.16.2.4	Ditching	133
3.7.16.2.5	Rescue Provisions	133
3.7.16.2.6	Emergency Oxygen Supply	133
3.7.16.3	Physical Characteristics	133
3.8	Precedence	134
3.8.1	Documents	134
3.8.2	Design and Performance	134
4	Quality Assurance Provisions	135
4.1	General	135
4.1.1	Responsibility for Tests	135
4.2	Quality Conformance Inspections	135
4.2.1	Reliability Testing	135
4.2.1.1	Reliability Tests	135
4.2.2	Engineering Test and Evaluation	135
4.2.3	Qualification Testing	136
4.2.4	Installation Testing	136
4.2.4.1	Installation Tests	136
4.2.5	Formal Performance Verification Tests and Demonstrations	136
4.2.5.1	Assembly and Launch of the Booster	136
4.2.5.1.1	Mating	136
4.2.5.1.2	Erection	136
4.2.5.1.3	Transport to Launch Facility	136
4.2.5.1.4	Propellant Loading	136
4.2.5.1.5	Serviceables Loading	136
4.2.5.1.6	Standby Operations	136
4.2.5.1.7	Launch Operations	136
4.2.5.2	Mission Operations	137
4.2.5.2.1	Lift Off and Boost Operations	137
4.2.5.2.2	Post-Staging Operations	137
4.2.5.2.3	Inspection, Maintenance and Repair Operations	137
4.2.5.2.4	Transport/Ferry Flight	138

TABLE OF CONTENTS, Contd

Paragraph No.		Page
4.2.5.2.5	Abort Operations	138
5	Preparation for Delivery	139
6	Notes	141
6.1	Intended Use	141
6.2	Reserved	141
6.3	Definitions	141
6.3.1	Weight Definitions	141
6.3.1.1	Dry Weight Empty	141
6.3.1.2	Booster Gross Weight	141
6.3.2	Flight Definitions.	141
6.3.3	Ascent	142
6.3.4	Staging	142
6.3.5	Intent of Qualification Testing	142
6.3.6	Qualification	142
6.3.7	Test and Evaluation	142
6.3.8	Major Malfunction	142
10	Appendix 10 (Reserved)	10-1
20	Appendix 20 Verification Methods	20-1

BOOSTER VEHICLE PRIME ITEM SPECIFICATION

PART I

1. SCOPE

1.1 Content. This specification establishes the performance, design, development, and test requirements for the space shuttle booster vehicle.

1.2 Organization of this document. This document is organized to follow the format requirements of MIL-STD-490, Appendix II as prescribed by NASA DRD CM 007M (MSC 03315) of contract NAS9-10960. The performance characteristics are so arranged that the CEI is treated as rocket functioning during the initial mission phases and as an airplane functioning during the other phases. The performance, therefore, is arranged along these functional lines and uses the functional flows wherever possible.

2. APPLICABLE DOCUMENTS

The following documents of the exact issue shown form a part of the specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

National Aeronautics and Space Administration (NASA)

Exhibit A of SSME Phase B Statement of Work, March 1, 1971	NASA Preliminary Contract End Item (CEI) Specification, Space Shuttle Main Engine

Military

MIL-B-5087B(2) 31 Aug 1970	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MIL-W-5088C 26 May 1965	Wiring, Aircraft, Installation of
MIL-H-5440E 11 Dec 1968	Hydraulic Systems, Aircraft Types I and II, Design, Installation and Data Requirements for
MIL-P-5518C(1) 9 July 1962	Pneumatic Systems, Aircraft, Design, Installation and Data Requirements for
MIL-G-6099A 15 April 1958	Generators and Regulators, Air-cooled, A-C, Aircraft, General Specification for
MIL-L-6503B 26 Oct 1967	Tests, Impact, Shock Absorber, Landing Gear, Aircraft
MIL-E-7016D 15 April 1965	Electric Load and Power Source Capacity, Aircraft, Analysis
MIL-W-7233 10 Jan 1963	Windshield Wiper System, Electric Aircraft, General Requirements for
MIL-P-7788D 14 April 1967	Panel, Information, Integrally Illuminated
MIL-E-8189D 1 Aug 1969	Electronic Equipment, Guided Missiles, General Specification for

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MIL-F-8785B 7 Aug 1969	Flying Qualities of Piloted Airplanes
MIL-M-8856A 29 Oct 1969	Missiles, Guided, Strength and Rigidity, General Specification for
MIL-A-8860 18 May 1960	Airplane Strength and Rigidity, General Specification for
MIL-A-8861 18 May 1960	Airplane Strength and Rigidity, Flight Loads
MIL-A-8862 18 May 1960	Airplane Strength and Rigidity, Landplane, Landing and Ground Handling Loads
MIL-A-8865 18 May 1960	Airplane Strength and Rigidity, Miscellaneous Loads
MIL-A-8867 18 May 1960	Airplane Strength and Rigidity, Ground Tests
MIL-A-8870 18 May 1960	Airplane Strength and Rigidity Vibration, Flutter and Divergence
MIL-R-9673B(2) 15 Sept 1961	Radiation Limits, Microwave and X-Radiation
MIL-M-18012B 20 July 1964	Markings for Aircrew Station Display, Design and Configuration of
MIL-E-25366C 27 Feb 1961	Electrical and Electronic Equipment and System, Guided Missile Installation of, General Specification for
MIL-E-25499C 23 March 1970	Electric System, Aircraft, Design and Installation of, General Specification for
MIL-P-25508D 16 Mar 1962	Propellant, Oxygen
MIL-G-25704A 13 June 1963	Generator System, A-C, Aircraft General Specification for
MIL-P-26517A 5 Dec 1969	Power Supply, Transformer - Rectifier, Aircraft, General Specification for

SPECIFICATIONS

Military (Continued)

MIL-L-27160B(3) 4 Dec 1969	Lighting, Instrument, Integral, White, General Spacification for
MIL-P-27201C 26 Sept 1969	Propellant, Hydrogen
MIL-P-27401B 19 Sept 1962	Propellant Pressurizing Agent, Nitrogen
MIL-P-27407(1) 9 May 1966	Propellant, Pressurizing Agent, Helium
MIL-S-38039A 21 Aug 1967	System, Illuminated Warning, Caution and Advisory, General Specification for
MIL-M-38310A 15 July 1966	Mass Properties Control, Requirements Missiles and Space Vehicles
MIL-E-38453(1) 4 May 1967	Environmental Control, General Specifications for
MIL-R-81261(A) 18 May 1955	Rain Repellent, Glass Window and Windshield, for In-Flight Application
MIL-W-81381(3) 15 May 1970	Wire, Electric, Polyimide - Insulated Copper and Copper Alloy
MIL-C-83723 26 May 1969	Connector, Electric, Circulator, Environment of Resisting General Specification for

Contractor

North American Rockwell, Space Division

SS613M0001 June 1971	System Specification for a Space Shuttle System
CP613M0002 June 1971	Orbiter Vehicle Prime Item Specification, Part I Space Shuttle
76Z0501 June 1971	Ground System Specification for a Space Shuttle System

STANDARDS

Military

MIL-STD-203E 1 Aug 1967	Aircrew Station Control and Displays for Fixed Wing Aircraft
MIL-STD-411C 21 Aug 1967	Aircraft Station Signals
MIL-STD-490(1) 1 Feb 1969	Specification Practices
MIL-STD-704A(1) 7 Feb 1968	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-803A-3 3 June 1968	Human Engineering Criteria
MIL-STD-850A 8 June 1967	Aircrew Station Vision Requirements for Military Aircraft
MIL-STD-1333 2 June 1969	Aircrew Station Geometry for Military Aircraft
MIL-STD-1472A 15 May 1970	Human Engineering, Design Criteria for Military Systems, Equipment and Facilities

National Aeronautics and Space Administration (NASA)

MSFC-STD-105	Synthetic Rubber, Age Control of

MANUALS

National Aeronautics and Space Administration (NASA)

NHB 6000.1(1A) Dec 1969	Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems Equipment and Associated Components
SP 8029 May 1969	NASA Space Vehicle Design Criteria (Structures) Aerodynamic and Rocket Exhaust Heating During Launch and Ascent
SP 8057 Jan 1971	Structural Design Criteria Applicable to Space Shuttle

MANUALS

National Aeronautics and Space Administration (NASA)(Continued)

NHB 8040.2 Jan 1970	Apollo Configuration Management Manual,
MM 8040.12 15 Mar 1971	MSFC Standard Contractor Configuration Requirements
MSCM 8080 26 April 1971	Manned Spacecraft Criteria and Standards

Military

AFDH 2	Design Handbook Series 2 Space Vehicles
AFSCM 80-1	Handbook of Instructions for Aircraft Designers, Vol. II, Guided Missiles
AFSCM 80-3	Handbook of Instructions for Aircraft Designers

OTHER PUBLICATIONS

Superintendent of Documents, U.S. Government Printing Office, Washington 26, D. C.	U. S. Standard Atmosphere, 1962

National Aeronautics and Space Administration (NASA)

NASA TM-X-53872 8 Sept 1970	Terrestial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle Development
NASA TM-X-53973 9 Feb 1970	Natural Environmental Criteria for the NASA Space Shuttle Program
MBC 03310	Operations Plan for Phase C/D (SD 71-103-3)
13M15000B 1 March 1971	Space Shuttle Vehicle/Engine 550K (SL) Interface Control Document

OTHER PUBLICATIONS (Continued)

Contractor

North American Rockwell Space Division

ICD SR 2.4.4-11186	Booster and Orbiter Interface Document
ICD SR 2.4.4-11189	Booster and M&R Facility Interface Document
ICD SR 2.4.4-11190	Booster and Launch Pad Interface Document
ICD SR 2.4.4-11191	Booster and Landing Sites Interface Document
ICD SR 2.4.4-11192	Booster and Tracking and Communication Interface Document

DRAWINGS

MSFC 85M03928	Parts Selection and Control Requirements for the Space Shuttle Vehicle and Engine
MSFC 85M03929	Space Shuttle Vehicle and Engine Parts Selection
MSFC 85M03885	Guidelines for Performing FMECA on the Space Shuttle

3. REQUIREMENTS

3.1 Item definition. The space shuttle booster vehicle, hereinafter referred to as the booster or CEI, shall be the first stage of the space shuttle vehicle as described in Specification SS613M001. The booster shall boost the second stage orbiter vehicle into the proper trajectory and achieve the required velocity for staging. The two stages shall have sequential firings, the orbiter firing initiated near the booster engine shutdown. The booster, with the orbiter mounted on its upper surface, shall launch vertically. After booster main engine shutdown and orbiter release, the booster shall return to its ground base through flight phases which include coast, hypersonic glide, transition, cruise, descent, approach, landing or go-around and landing. The booster shall also be capable of ferry flights from one site to another; the flight phases will be takeoff, climb, cruise, descent, approach, landing or go-around and landing. The general arrangement and representative dimensions of the booster are shown in Figures 3.2.2.2-1 and 3.2.2.2-2.

3.1.1 Item diagrams. The sequence and logic of the booster operational functions shall be shown in the first level functional flow diagram. Lower level flow diagrams are presented in Figures 3.1.1-1 through 3.1.1-6. Details of these diagrams are contained in MSC 03310.

3.1.2 Interface definition. The CEI shall interface with the other areas of the space shuttle as shown in the block diagram, Figure 3.1.1.1-7. The detail interfaces shall conform to the interface requirements in the following documents.

	Interface Control Document No.	Areas of Interface
a.	ICD SR 2.4.4-11186	Booster Vehicle and Orbiter Vehicle
b.	ICD	Booster and storage area
c.	ICD SR 2.4.4-11189	Booster and M&R facility
d.	ICD SR 2.4.4-11190	Booster and launch pad
e.	ICD SR 2.4.4-11191	Booster and recovery facility
f.	ICD	Booster and MP&S facility
g.	ICD	Booster and control center
h.	ICD SR 2.4.4-11192	Booster and track and communication network Space shuttle vehicle/engine 550K (SL)

3.1.2.1 Subsystem interfaces. The functional interfaces of the subsystems which are components in this CEI, are specified in the functional block diagrams showing interfaces for each of those subsystems and are contained in paragraph 3.7 herein. The component subsystems are related to the CEI as shown in Figure 3.1.2.1-1.

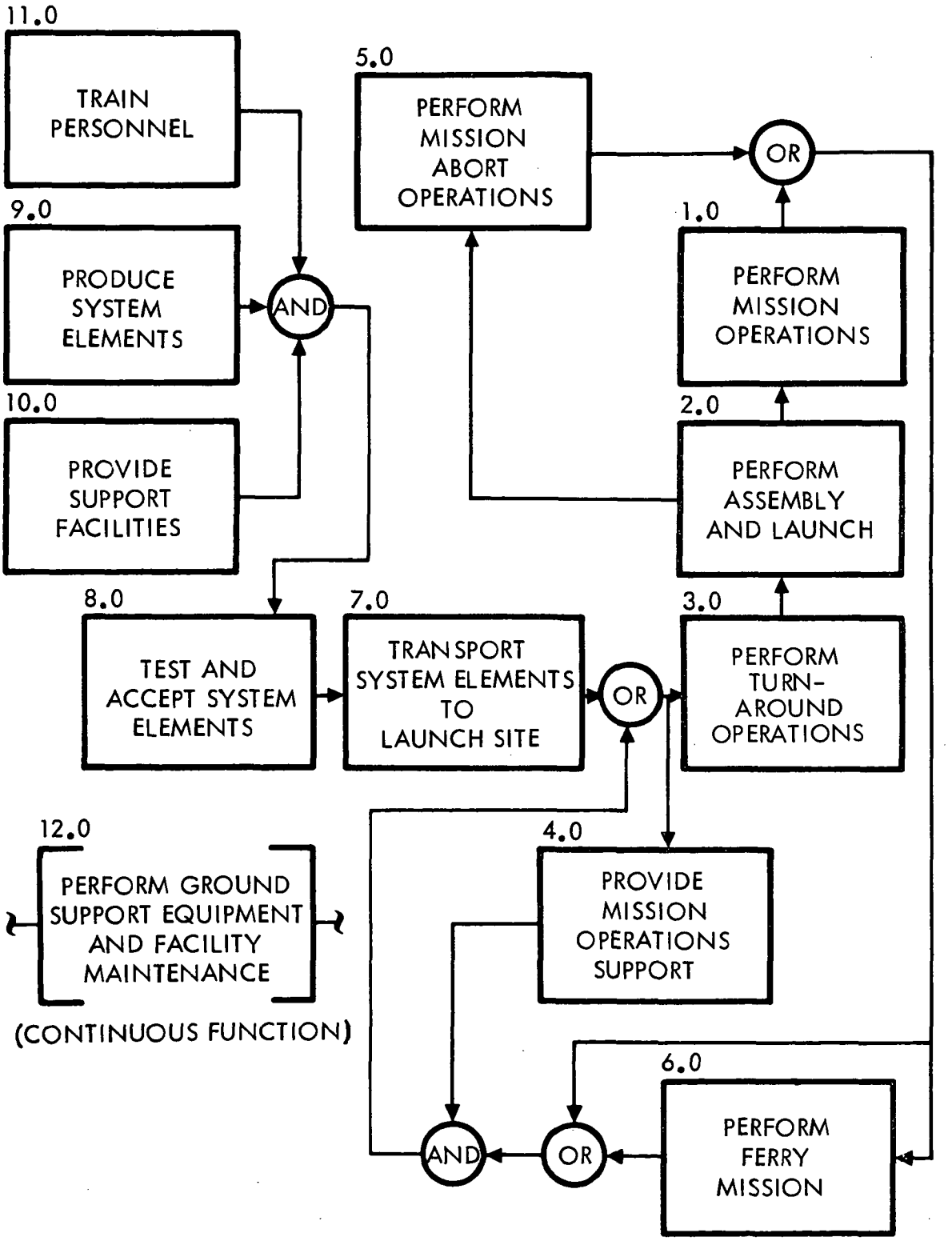

Figure 3.1.1-1. Top level functional flow block diagram

Functional Block Descriptions for Top Level Diagram (Figure 3.1.1-1)

1.0 Perform Mission Operation — Covers all activities from Shuttle Vehicle liftoff through landing rollout. The function includes all orbiter and booster operations through launch, staging, orbit, re-entry, fly-back and landing phases.

2.0 Perform Assembly and Launch — Includes mission planning and launch support: payload integration, vehicle mating, erection, transport and assembly (not necessarily in that order), propellant loading, crew and passenger loading, final servicing, checkout, launch countdown, ignition and release.

3.0 Perform Turnaround Maintenance Operations — Begins with transport (taxi or tow) to safing area, includes post-flight safing, crew and passenger egress, cargo unloading, transport to the maintenance and repair facility, inspection, post-flight data processing, maintenance, repair, refurbishment, post-maintenance, checkout, storage (as required) and ends with preparation for mating the vehicle to the orbiter.

4.0 Provide Mission Operations Support — Shall include the pre-mission, mission, and post-mission operations management functions. Contents of mission operations support shall include but not be limited to:

a. Mission Planning

b. Mission Profiles

c. Communication and Air Traffic Control

5.0 Perform Mission Abort Operations — Includes all orbiter and booster abort possibilities starting with pad abort and progressing through launch, staging, on-orbit, re-entry, cruise and landing.

6.0 Perform Ferry Mission — After landing at alternate site, includes post-flight safing, crew and passenger egress, and may include cargo unloading and vehicle storage. Includes ferry preparations pre-flight checkout, fueling, preparation of flight plans and ferry flight operations, ferry aborts, ending with landing rollout.

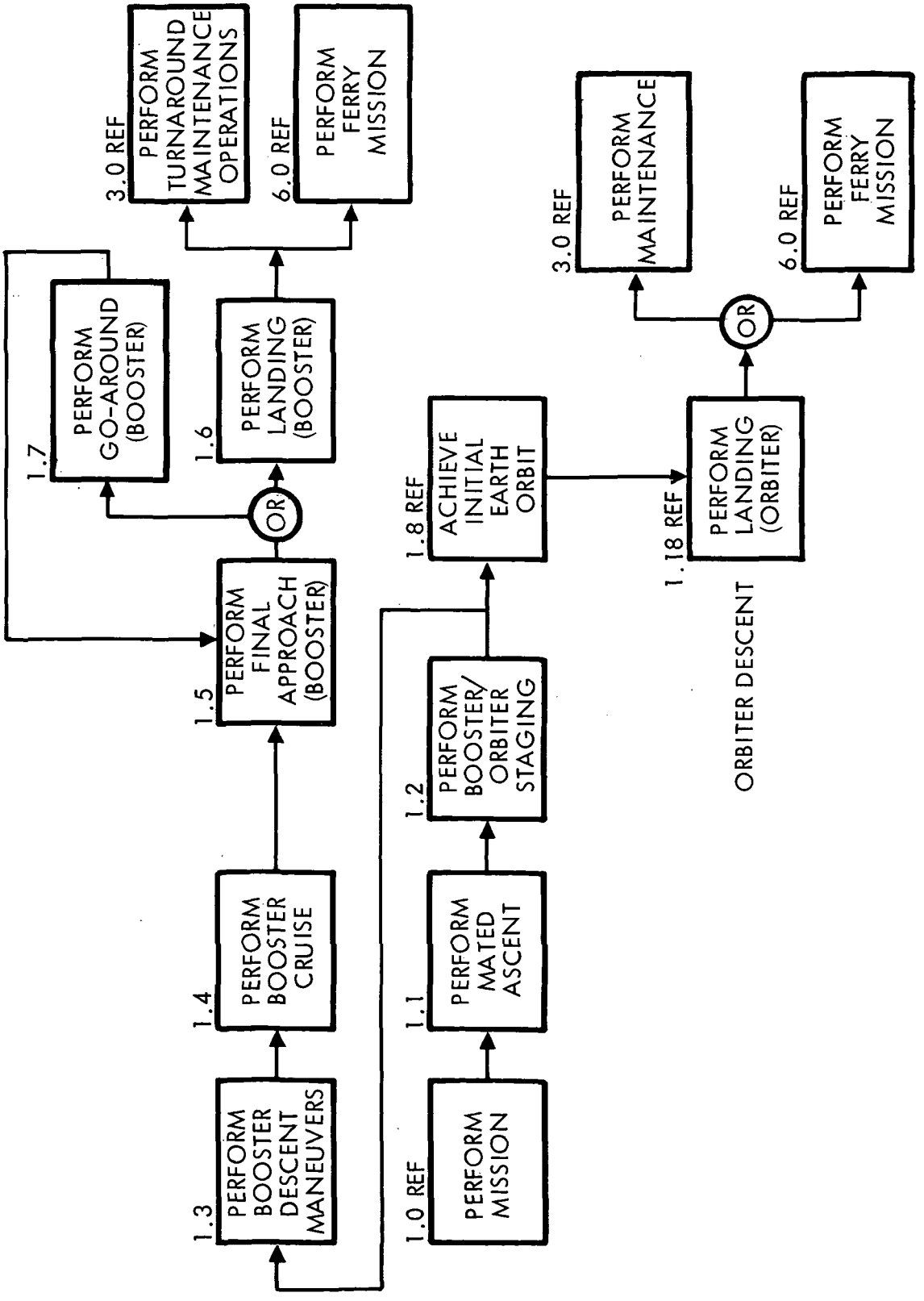

Figure 3.1.1.1-1. Mission operations

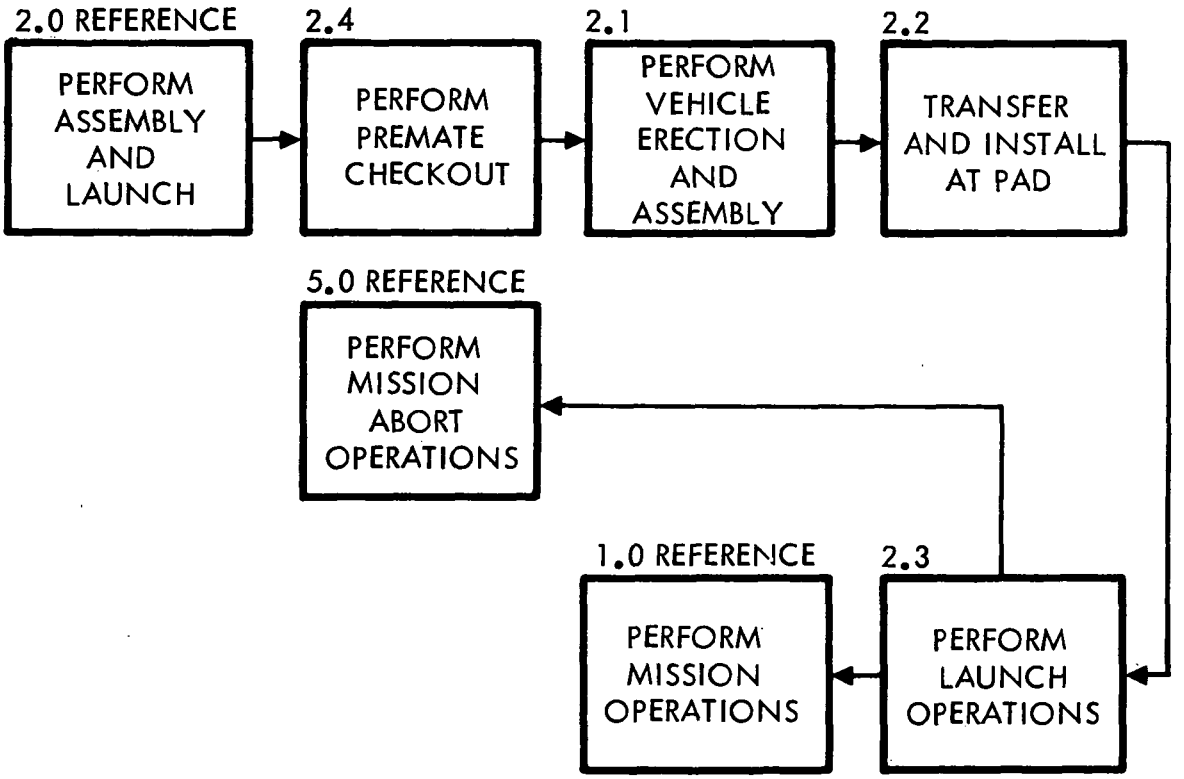

Figure 3.1.1-2. Assembly and launch functional flow

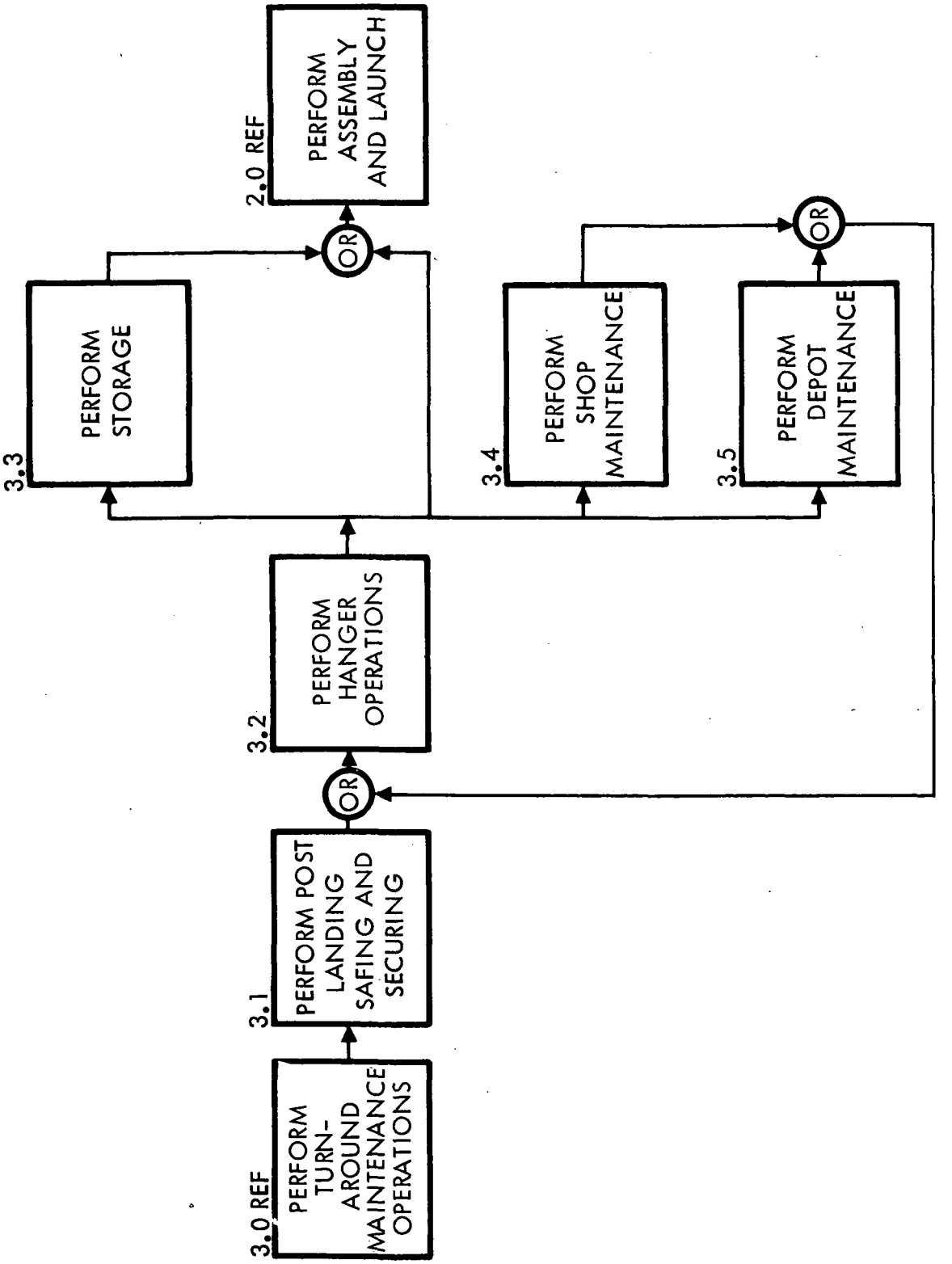

Figure 3.1.1-3. Inspection and/or maintenance and repair operation

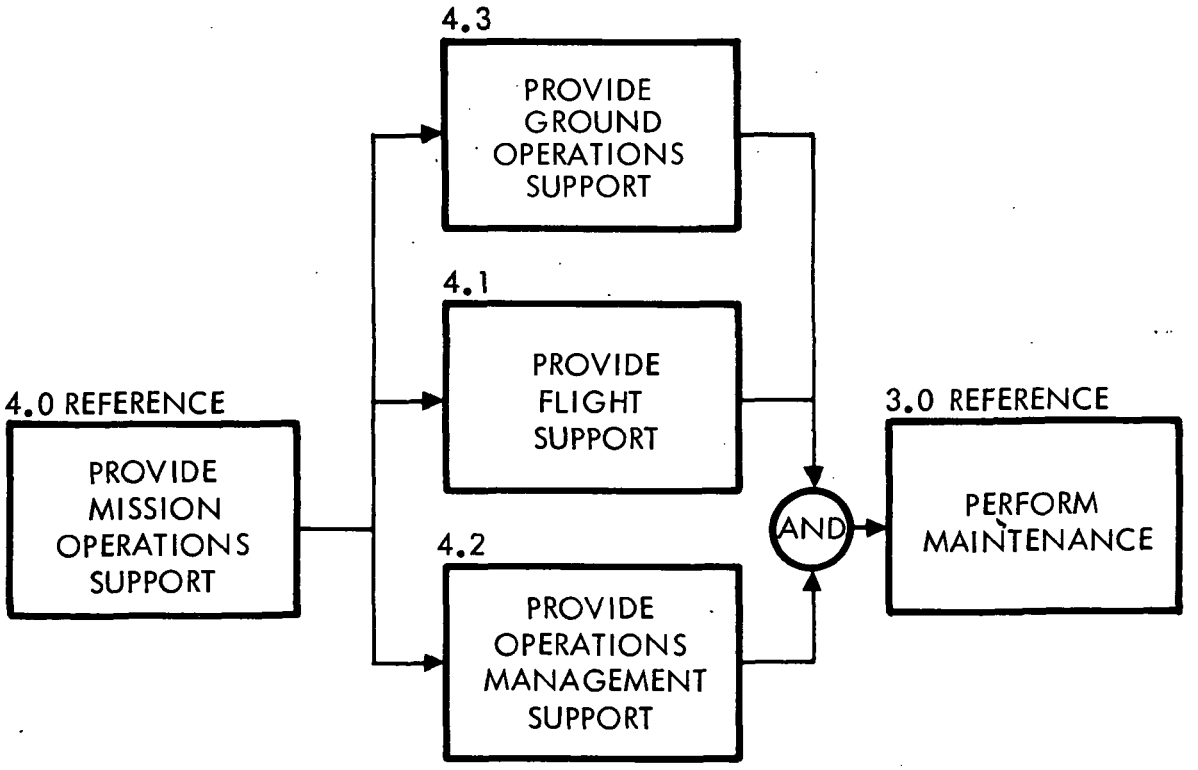

Figure 3.1.1-4. Flight support functional flow

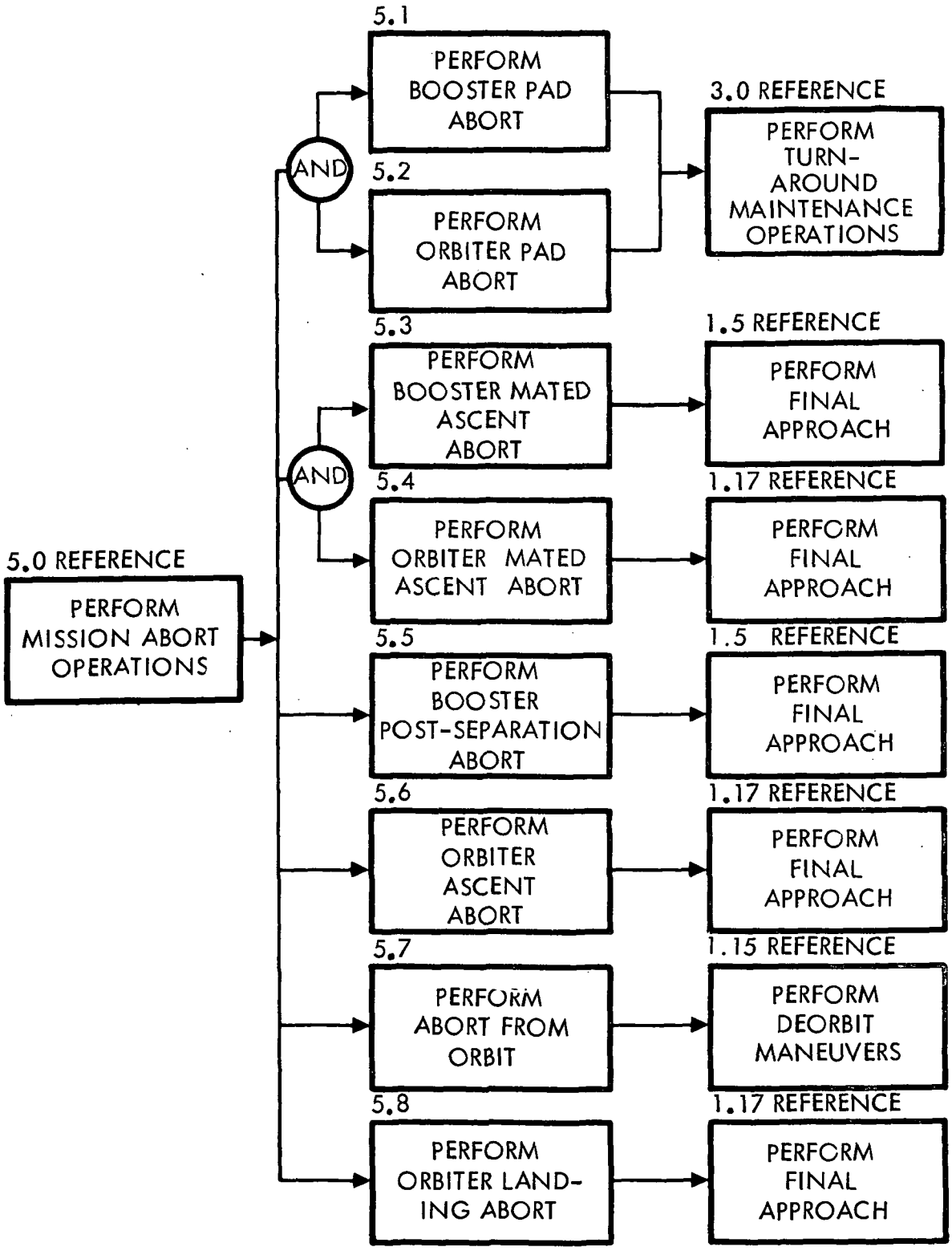

Figure 3.1.1-5. Perform abort operation

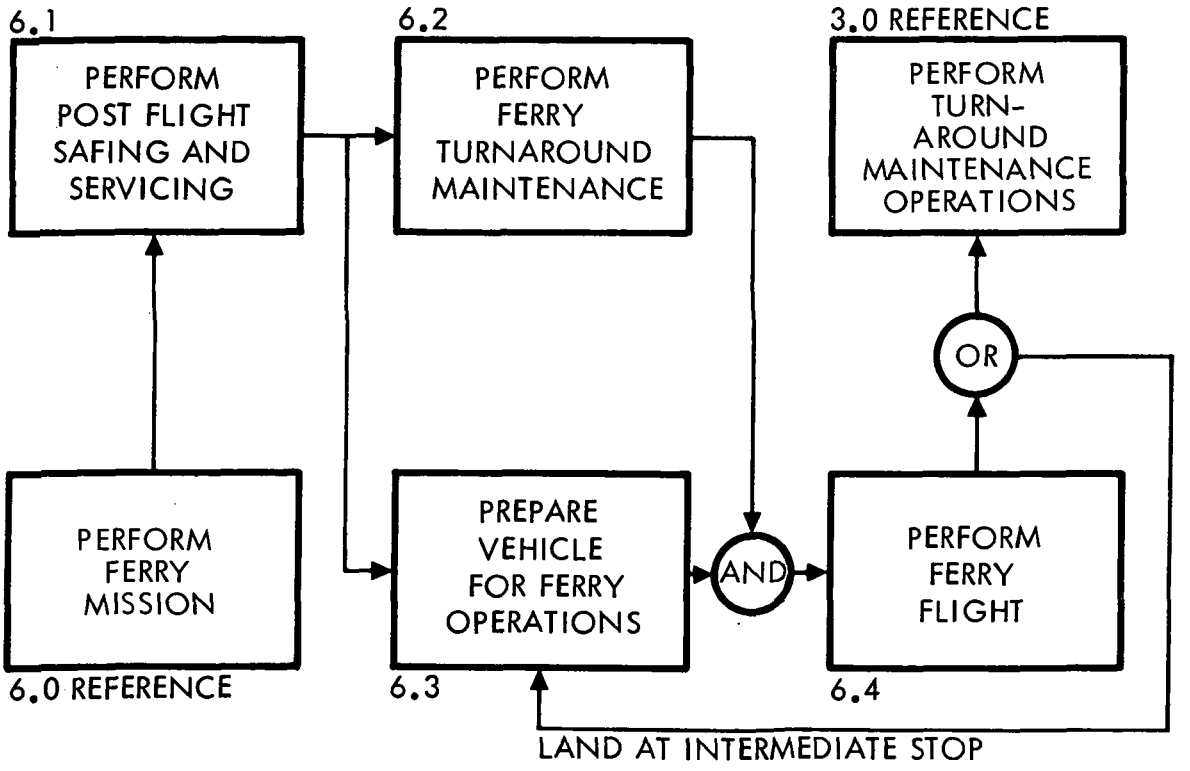

Figure 3.1.1-6. Ferry mission functional flow

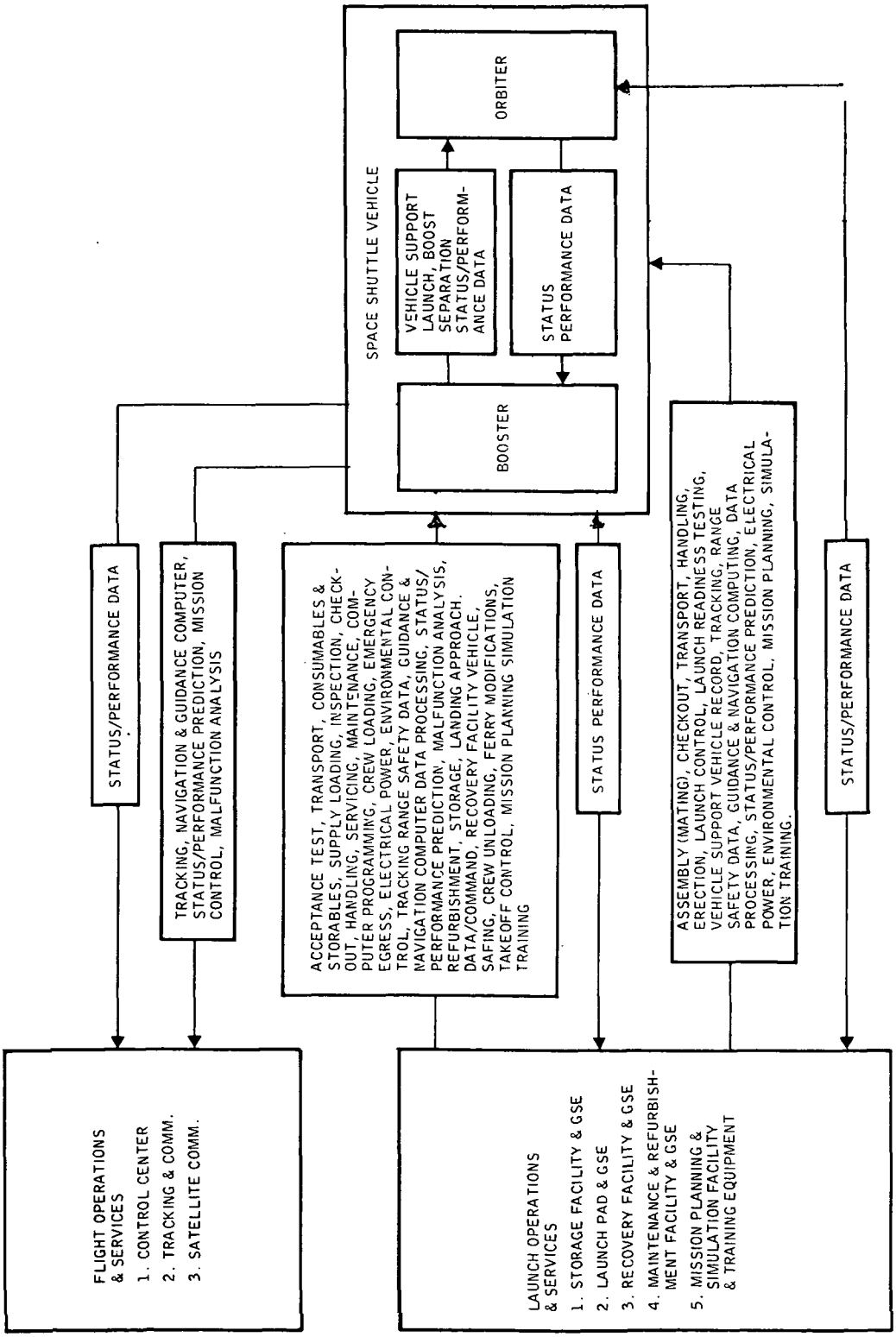
SPACE SHUTTLE VEHICLE
ORBITER
BOOSTER
VEHICLE SUPPORT LAUNCH, BOOST SEPARATION STATUS/PERFORMANCE DATA
STATUS PERFORMANCE DATA
STATUS/PERFORMANCE DATA
TRACKING, NAVIGATION & GUIDANCE COMPUTER, STATUS/PERFORMANCE PREDICTION, MISSION CONTROL, MALFUNCTION ANALYSIS
ACCEPTANCE TEST, TRANSPORT, CONSUMABLES & STORABLES, SUPPLY LOADING, INSPECTION, CHECK-OUT, HANDLING, SERVICING, MAINTENANCE, COMPUTER PROGRAMMING, CREW LOADING, EMERGENCY EGRESS, ELECTRICAL POWER, ENVIRONMENTAL CONTROL, TRACKING RANGE SAFETY DATA, GUIDANCE & NAVIGATION COMPUTER DATA PROCESSING, STATUS/PERFORMANCE PREDICTION, MALFUNCTION ANALYSIS, REFURBISHMENT, STORAGE, LANDING APPROACH, DATA/COMMAND, RECOVERY FACILITY VEHICLE, SAFING, CREW UNLOADING, FERRY MODIFICATIONS, TAKEOFF CONTROL, MISSION PLANNING SIMULATION TRAINING
STATUS PERFORMANCE DATA
ASSEMBLY (MATING), CHECKOUT, TRANSPORT, HANDLING, ERECTION, LAUNCH CONTROL, LAUNCH READINESS TESTING, VEHICLE SUPPORT VEHICLE RECORD, TRACKING, RANGE SAFETY DATA, GUIDANCE & NAVIGATION COMPUTING, DATA PROCESSING, STATUS/PERFORMANCE PREDICTION, ELECTRICAL POWER, ENVIRONMENTAL CONTROL, MISSION PLANNING, SIMULATION TRAINING.
STATUS/PERFORMANCE DATA
FLIGHT OPERATIONS & SERVICES
1. CONTROL CENTER
2. TRACKING & COMM.
3. SATELLITE COMM.
LAUNCH OPERATIONS & SERVICES
1. STORAGE FACILITY & GSE
2. LAUNCH PAD & GSE
3. RECOVERY FACILITY & GSE
4. MAINTENANCE & REFURBISHMENT FACILITY & GSE
5. MISSION PLANNING & SIMULATION FACILITY & TRAINING EQUIPMENT

Figure 3.1.1-7. Space shuttle system interfaces

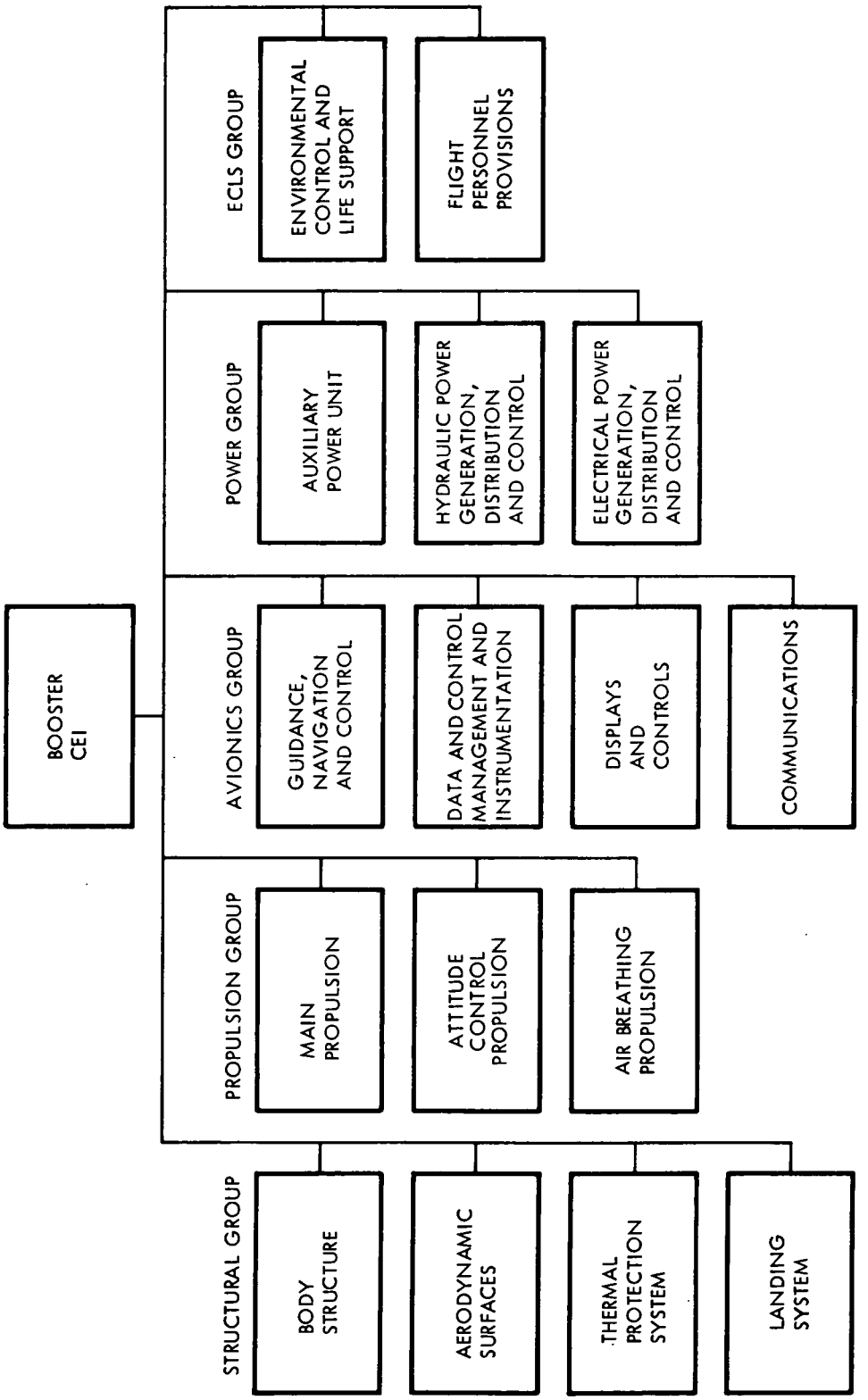

Figure 3.1.2.1-1. Component subsystems of booster

3.1.3 Major component list. The booster shall be composed of the following subsystems:

a. Body structure.

b. Aerodynamic surfaces.

c. Thermal protection.

d. Landing system.

e. Main propulsion.

f. Attitude control propulsion.

g. Air-breathing propulsion.

h. Guidance, navigation and control.

i. Data and control management.

j. Displays and controls.

k. Communications.

l. Auxiliary power unit.

m. Hydraulic power generation, distribution and control.

n. Electric power generation, distribution and control.

o. Environmental control and life support.

p. Flight personnel provisions.

3.1.4 Government-furnished property list. The booster shall be designed to incorporate the following Government-furnished property:

Quantity	Specification No. or Part No.	Nomenclature
12	Exhibit A of SSME	Engine, Main Space Shuttle (Booster)
12	Phase B Statement of work	Turbofan Engine

3.1.5 Government-loaned property list. The following Government property shall be utilized by the contractor in the production of the booster vehicle:

TBD

3.2 Characteristics

3.2.1 Performance. The performance of the booster shall be based on the use of 12 GFE main engines, having the performance and other characteristics specified in the shuttle main engine specification. All performance and fuel requirements are based on the terrestrial environmental characteristics of a day as defined in TM-X-53872 and the space environmental conditions as defined by TM-X-53957 as specified in 3.2.5 herein. In general, the performance specified herein is mission oriented, the mission being specified in the space shuttle system specification SS613M0001.

3.2.1.1 Perform mission. The performance specified herein includes the following phases: mated ascent, staging, entry and transition maneuvers, cruise, descent, approach and landing. The performance of the booster during the mated ascent and staging is predicated on the use of an orbiter and payload, described in specification CP613M0002. The mass properties and other physical characteristics of the orbiter-payload combination affecting the performance of the booster are described in ICD SR 2.4.4-11186, booster-orbiter interface document.

3.2.1.1.1 Mated ascent. The booster, mated to the orbiter vehicle, shall be capable of liftoff in a near vertical attitude with a thrust/combined vehicles weight ratio of 1.30 minimum. The booster shall be capable of boosting a 900,000 pound orbiter vehicle to an altitude 232,500 ±7500 feet, to a final velocity of 10,750 ±150 feet per second at a flight path angle of 6 ±1 degrees with a single engine out. The booster shall be capable of an ascent along any azimuth. During ascent the steady-state axial loading shall not exceed 3 g's. During the ascent the dynamic pressure-angle of attack product ($q\alpha$) shall not exceed 2800 degrees-pounds per square foot and dynamic pressure-side slip angle product ($q\beta$) shall not exceed 2400 degrees-pounds per square foot.

3.2.1.1.1.1 Performance characteristics (Functions). The CEI shall be capable of the flight performance presented graphically in Figures 3.2.1.1.1.1-1 through 3.2.1.1.1.1-3 (see paragraph 6.3 for definitions). During this phase the functions crossing the interfaces between the CEI and other items shall be those shown in Figure 3.2.1.1.1.1-5.

3.2.1.1.1.1.1 Rate of response to external influences. The CEI shall be capable of positive control of the mated booster/orbiter combination and the booster only in all external disturbances (winds, shears, gusts, etc) as specified in MSFC TM-X-53872.

3.2.1.1.1.1.2 Propellant rate and control. The CEI shall be capable of providing propellants as follows:

Propellant flow rate (See 3.7.5.2.3 for conditions)	16,500 lb/sec
Mixture ratio	Emergency power level 6 ±2%
	Normal power level range 5.5 to 6.5

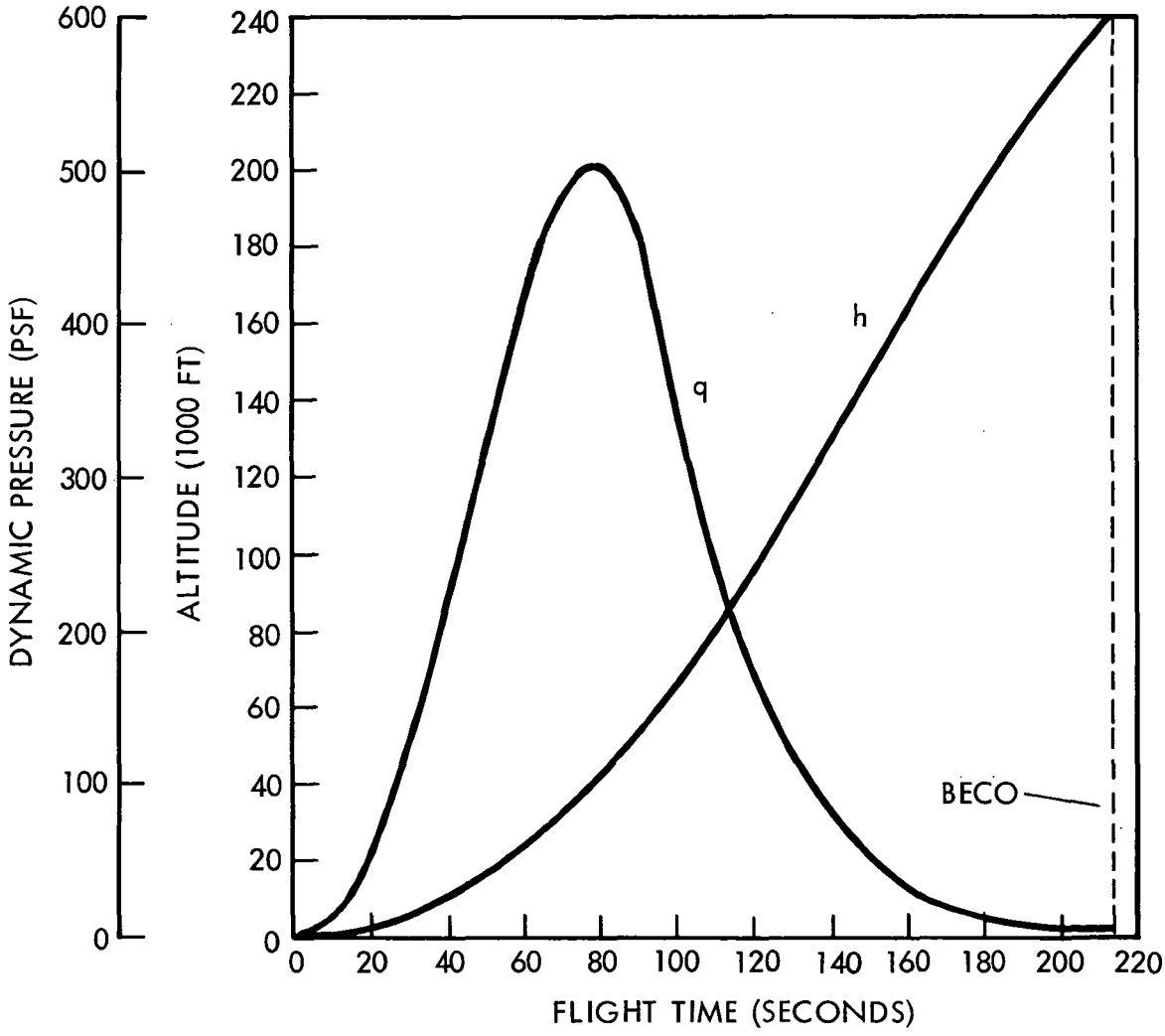

Figure 3.2.1.1.1.1-1 Flight performance during ascent

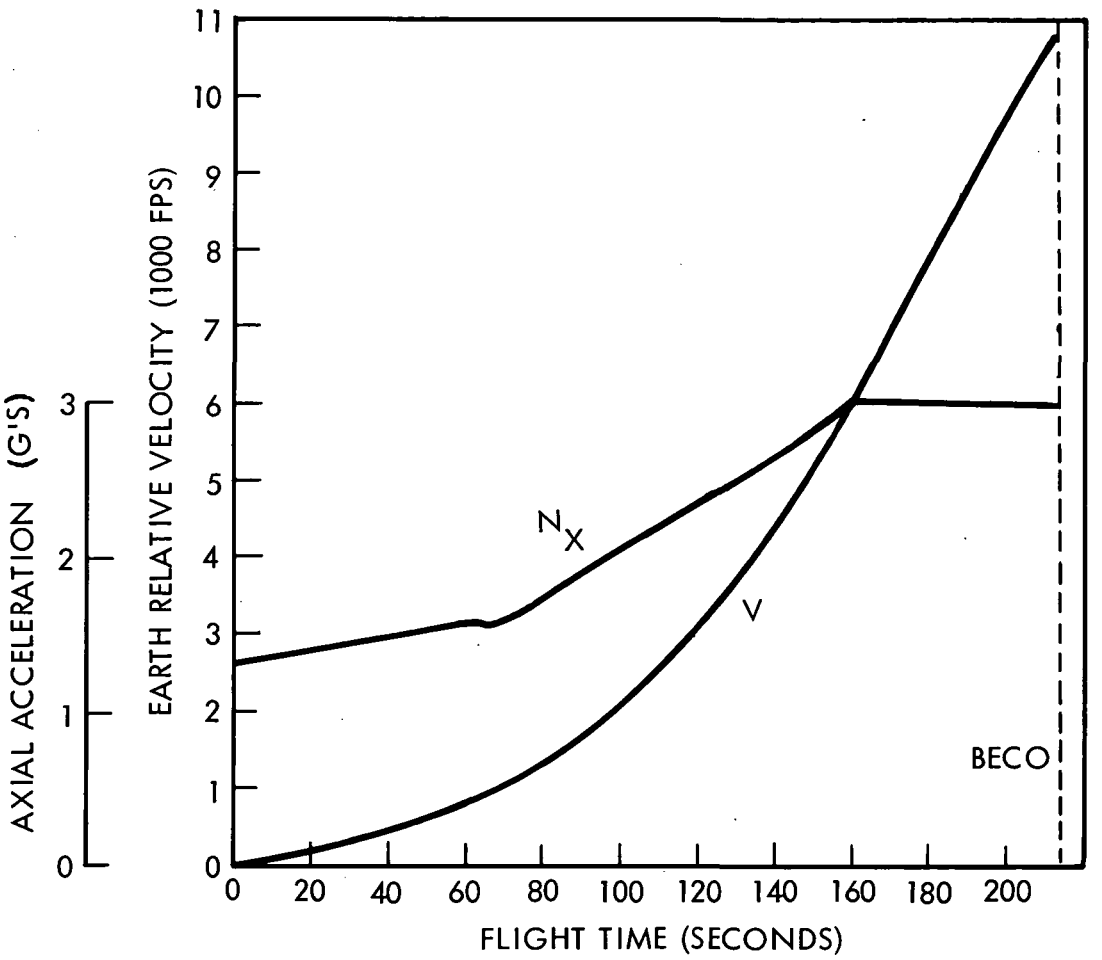

Figure 3.2.1.1.1.1-2 Flight performance during ascent

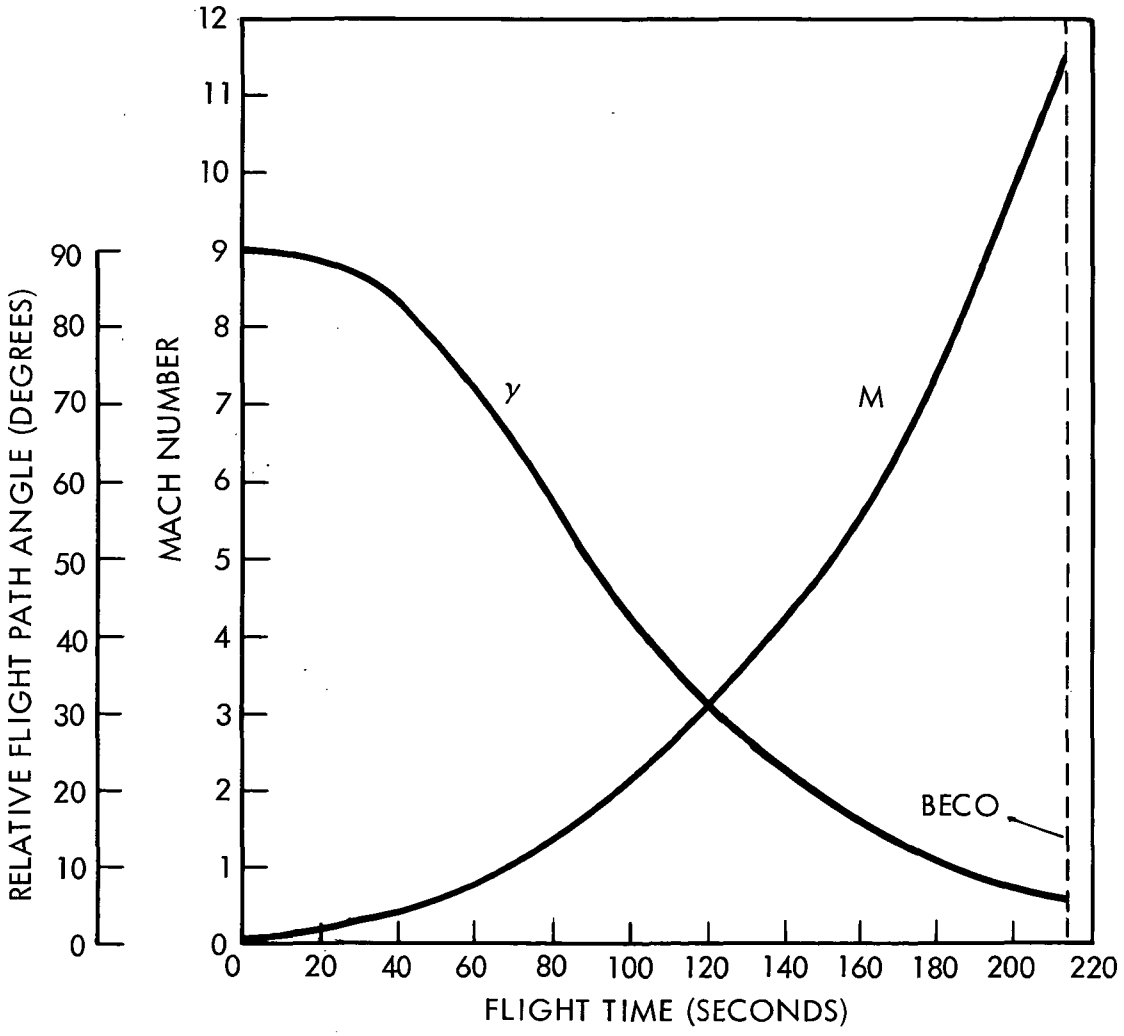

Figure 3.2.1.1.1.1-3 Flight performance during ascent

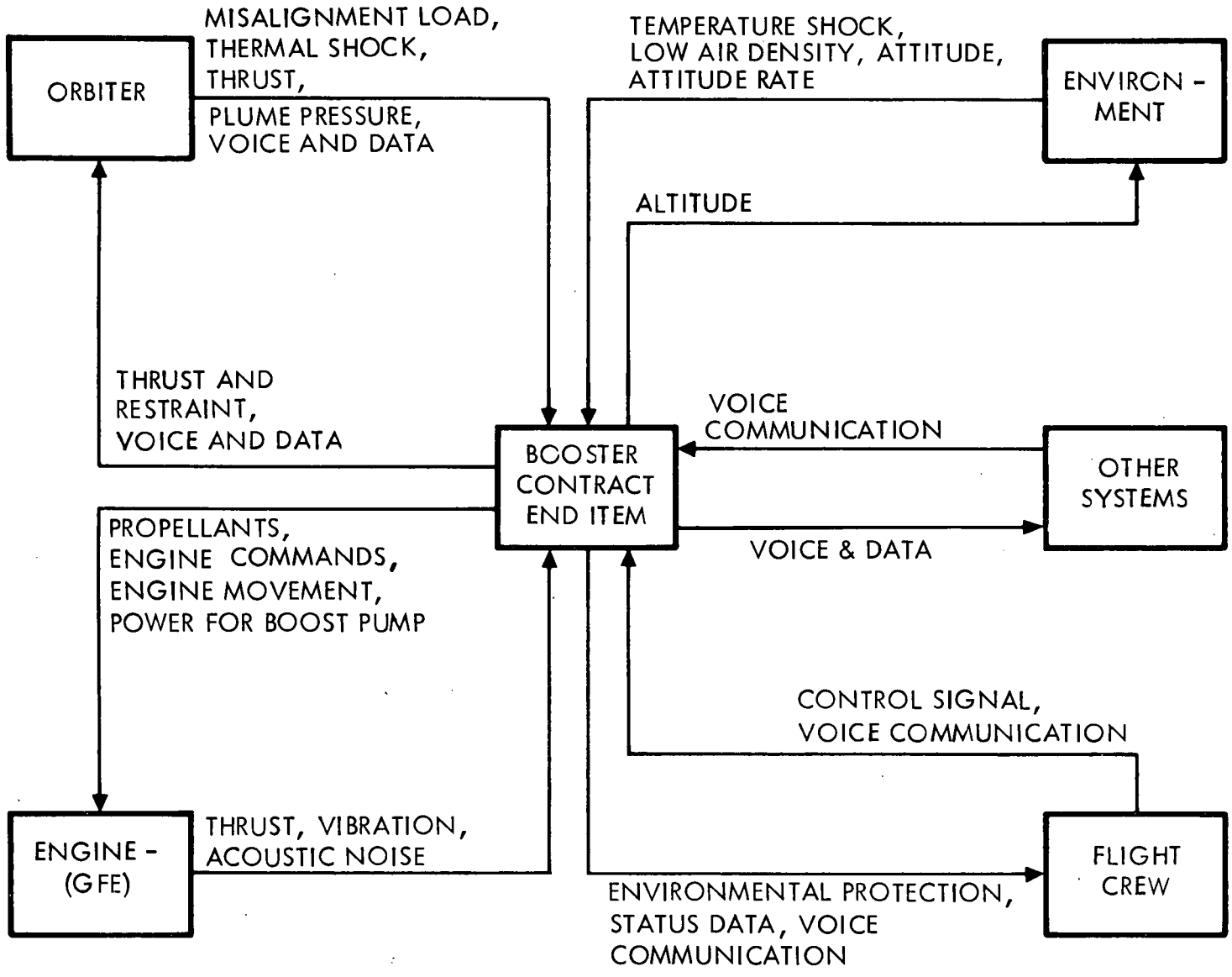

Figure 3.2.1.1.1.1-4 Block diagram of interfaces with booster during ascent and staging

Throttling range	50	to	109	% of full thrust
Contamination limits	as specified in 13M15000			

3.2.1.1.1.1.3 Communication rates. The CEI shall be capable of providing the following communications, at frequencies as follows:

a. Voice 225 - 400 MHz AM modulation

b. Data exchange with orbiter

c. Data 225 - 400 MHz AM modulation (down data only-data rate TBD)

3.2.1.1.2 Booster/orbiter staging. The CEI, with one engine out, shall be capable of releasing a functioning orbiter within the staging envelope specified in 3.2.1.1.1. Release shall be within 7 seconds of the initiate signal while at a point attitude of TBD ±2 degrees (inertial) about all three axes with a roll, pitch and yaw rate of zero ±2 degrees per second (see 6.3.4 and 3.2.1.3).

3.2.1.1.2.1 Performance characteristics. The CEI shall be capable of the flight performance specified in ICD SR 2.4.4-11186. During this phase the functions crossing the interface between the CEI and other items will be those shown in Figure 3.2.1.1.1.1-5.

3.2.1.1.2.1.1 Response rate (speed of response). See ICD SR 2.4.4-11186

3.2.1.1.2.1.2 Propellant rate and control. See ICD 13M15000

3.2.1.1.2.1.3 Communication rates. Same as 3.2.1.1.1.1.3.

3.2.1.1.3 Entry and transition flight phase. The booster entry and transition maneuver shall minimize the required cruise back range while not exceeding a load factor as stated in paragraph 3.2.2.4 herein. This operational sequence will end at a booster altitude of 20,000 feet. The booster shall be capable of deploying and starting its airbreathing engines during the terminal stage of this phase.

3.2.1.1.3.1 Flight characteristics. The CEI shall be capable of the flight performance presented graphically in Figures 3.2.1.1.3.1-1 through 3.2.1.1.3.1-3. During this phase, the functions crossing the interface between the CEI and other items will be those shown in Figure 3.2.1.1.3.1-4.

3.2.1.1.3.1.1 Center of gravity location. Same as 3.2.1.1.4-1.

3.2.1.1.3.1.2 Control. Appropriate control laws will be used to phase out reaction control thruster as the aerodynamic control surfaces become effective. The CEI shall be capable of reaction control to at least the following fail-safe angular accelerations:

Pitch	0.3 deg/sec^2	Roll	0.3 deg/sec^2	Yaw	1.0 deg/sec^2

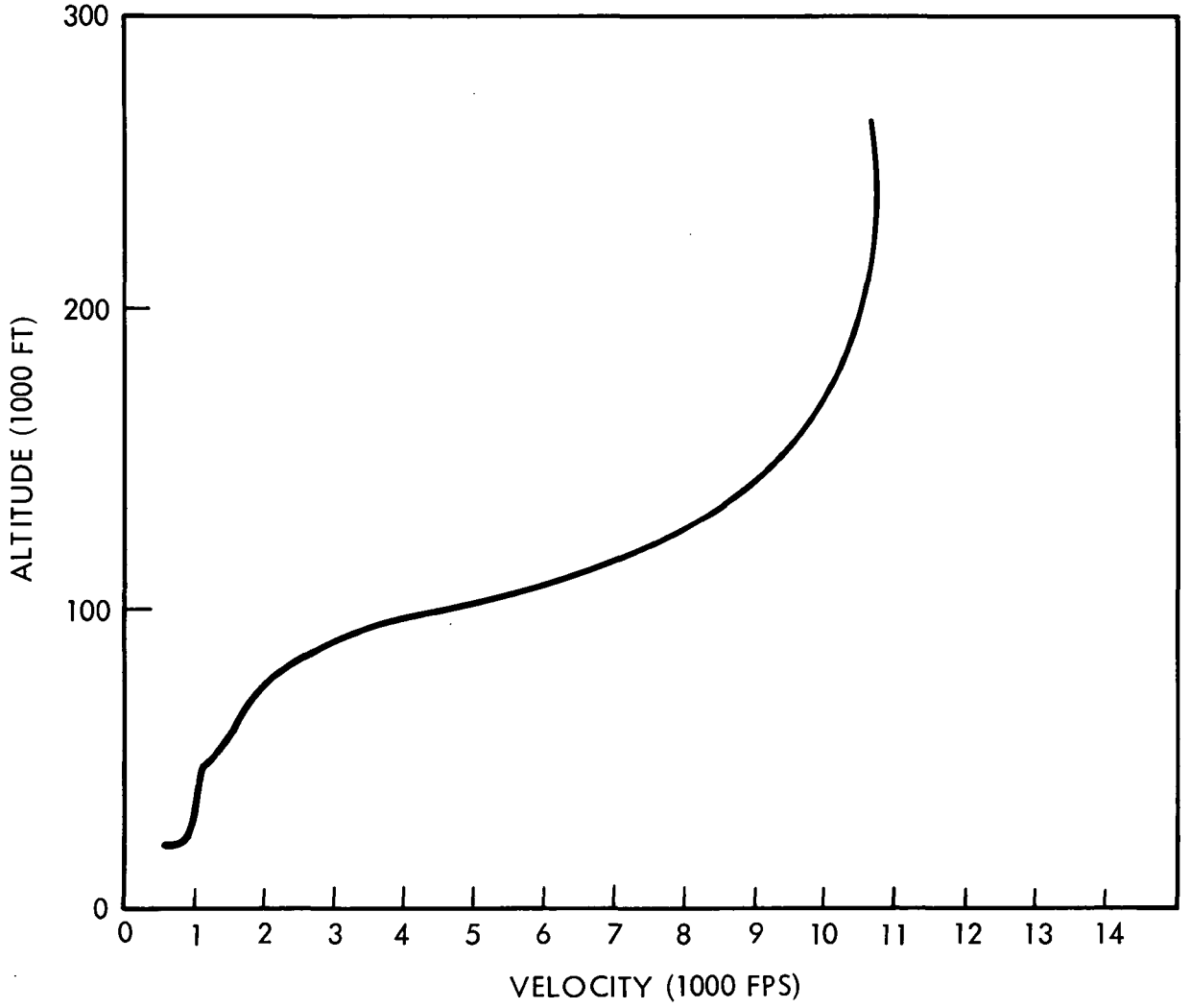

Figure 3.2.1.1.3.1-1 Flight performance during entry and transition

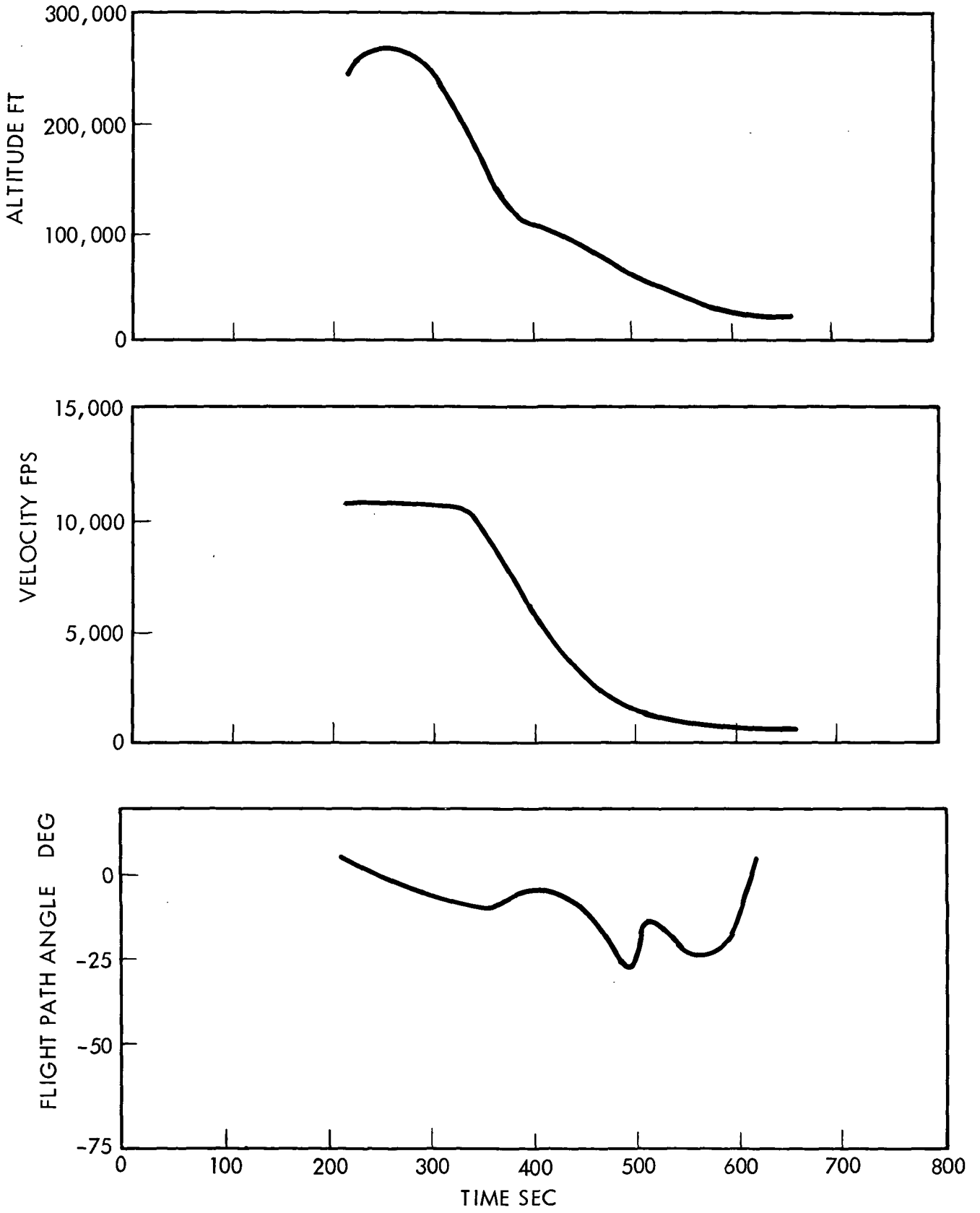

Figure 3.2.1.1.3.1-2 Flight performance during entry/transition

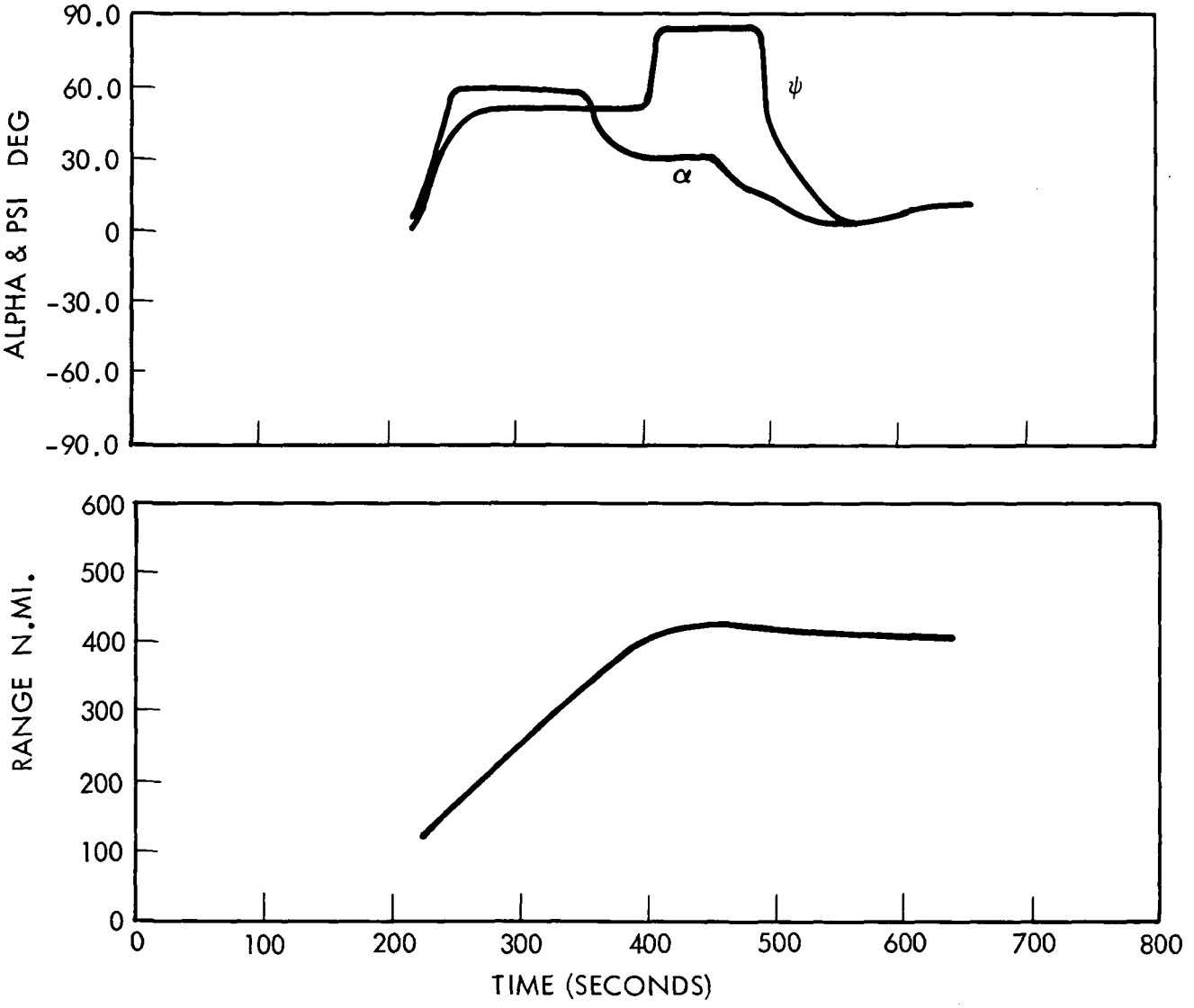

Figure 3.2.1.1.3.1-3 Flight performance during entry and transition

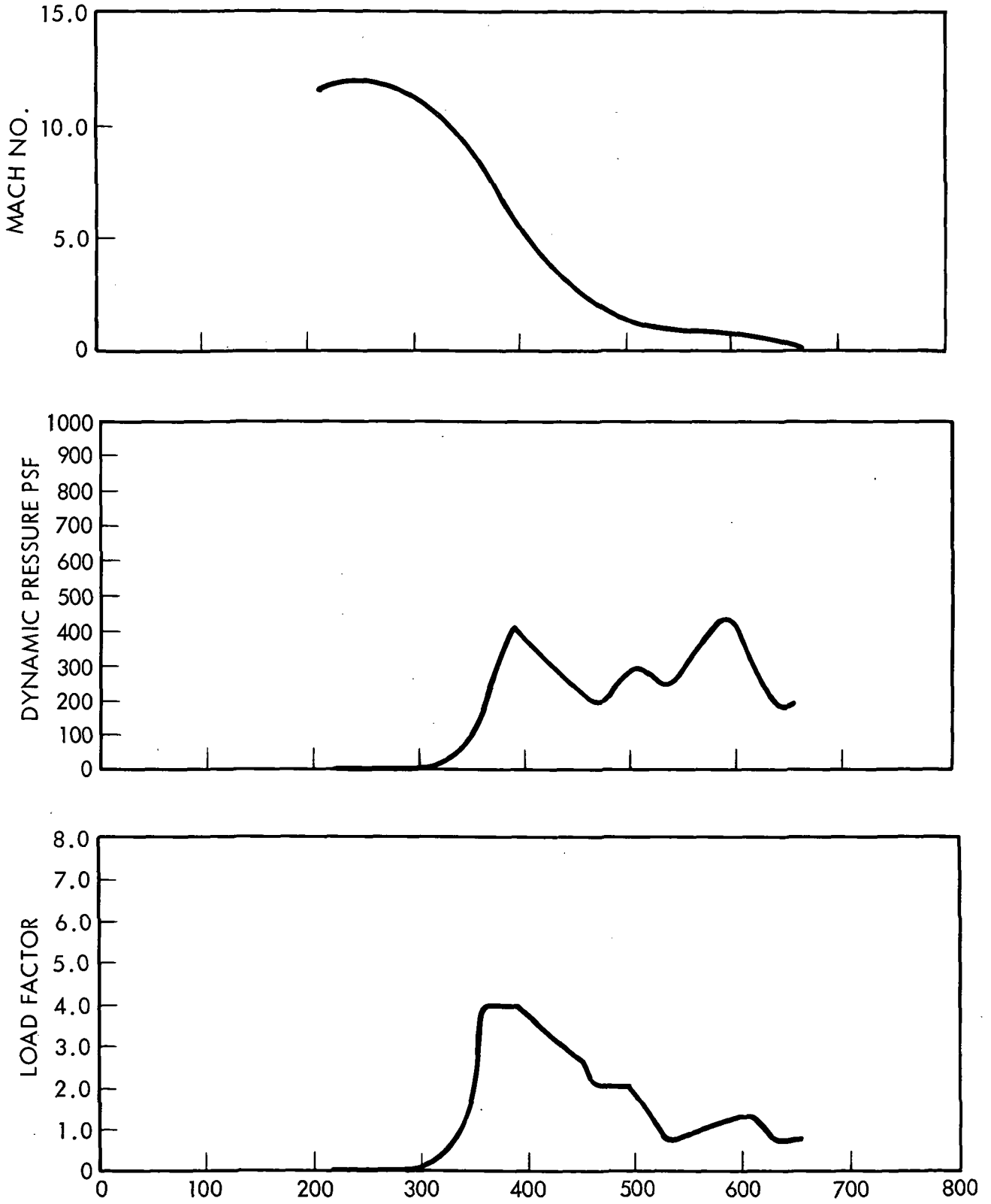

Figure 3.2.1.1.3.1-4 Flight performance during entry and transition

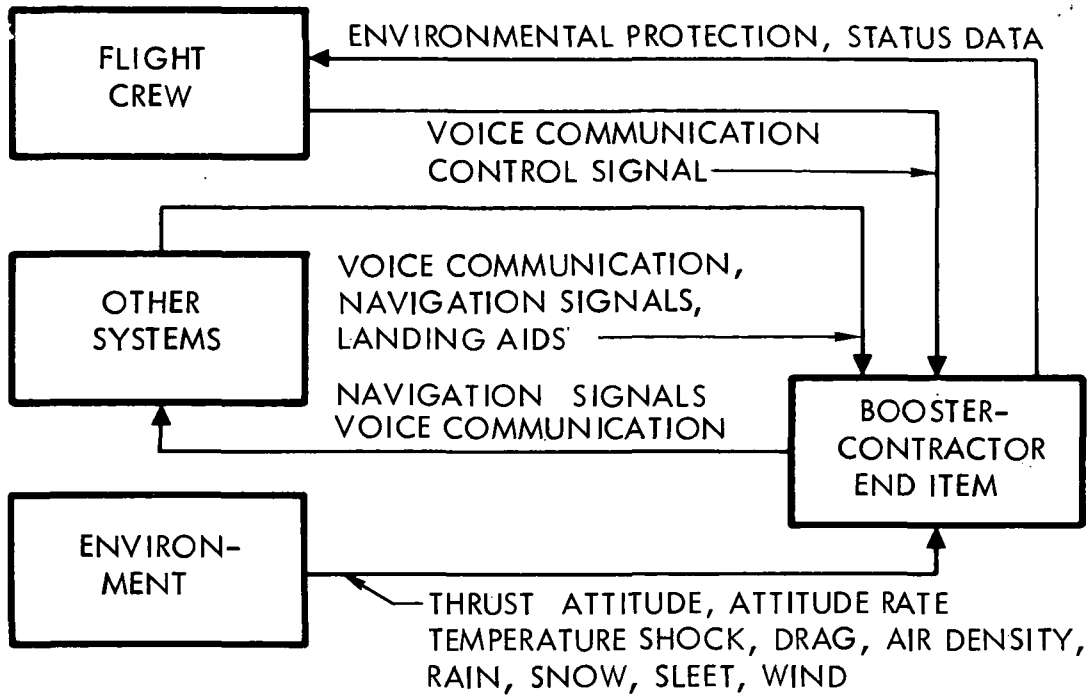
FLIGHT CREW
ENVIRONMENTAL PROTECTION, STATUS DATA
VOICE COMMUNICATION CONTROL SIGNAL
OTHER SYSTEMS
VOICE COMMUNICATION, NAVIGATION SIGNALS, LANDING AIDS
NAVIGATION SIGNALS VOICE COMMUNICATION
BOOSTER-CONTRACTOR END ITEM
ENVIRON-MENT
THRUST ATTITUDE, ATTITUDE RATE TEMPERATURE SHOCK, DRAG, AIR DENSITY, RAIN, SNOW, SLEET, WIND

Figure 3.2.1.1.3.1-5 Block diagram of interfaces with booster during reentry and flight

3.2.1.1.3.1.3 Communication rates. Same as 3.2.1.1.1.1.3.a.

3.2.1.1.4 Cruise back flight. The booster shall be capable of performing a 400 nautical mile cruise back to the launch site or to an alternate landing site under standard day conditions with one airbreathing engine inoperative against the headwinds defined by 3.2.5.1. Flying qualities shall be as defined in 3.3.8.13. The booster shall be capable of performance within the limits specified by Figures 3.2.1.1.4-1 and 3.2.1.1.4-2.

3.2.1.1.4.1 Communication rates. The CEI shall be capable of providing communications at the following rates and frequencies:

a.	Voice and data	Same as 3.2.1.1.1.3.a
b.	Recovery beacon	243 MHz

3.2.1.1.5 Descent. During the descent from cruise altitude to the sea level approach altitude, fuel calculations shall apportion fuel consumption and the range calculations shall credit distance. Flying qualities shall be as defined in 3.3.8.13. The booster shall be capable of performance within the limits specified by Figures 3.2.1.1.4-1 and 3.2.1.1.4-2.

3.2.1.1.5.1 Communication rates. The CEI shall be capable of providing communications at the following rates and frequencies:

a.	Voice and Data	Same as 3.2.1.1.1.1.3.a
b.	Recovery beacon	243 MHz
c.	Precision ranging system interrogator	S Band, TBD modulation
d.	Radar altimeter	4100-4300 MHz

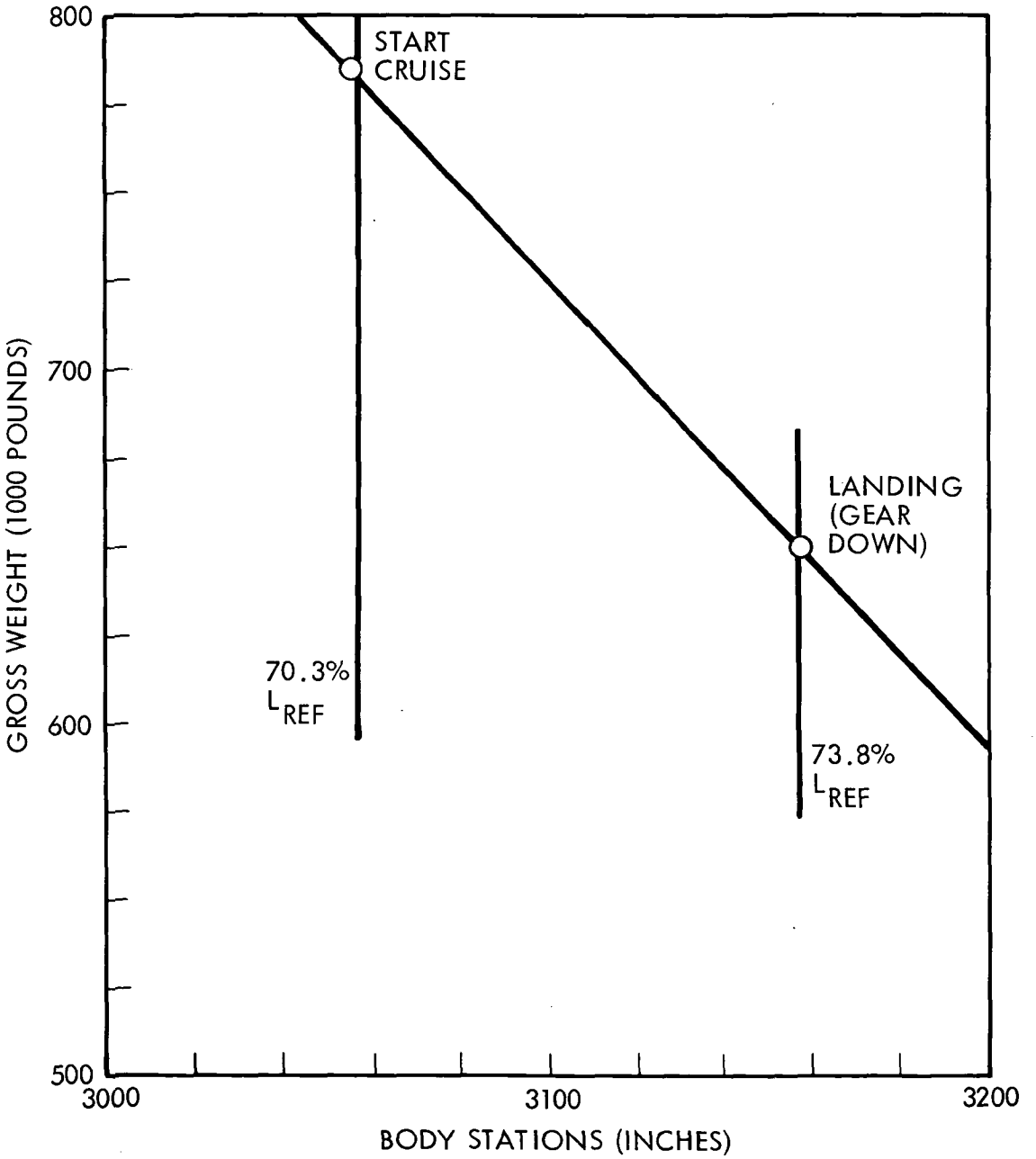

Figure 3.2.1.1.4-1 Center of gravity range envelope for cruise back flight phase

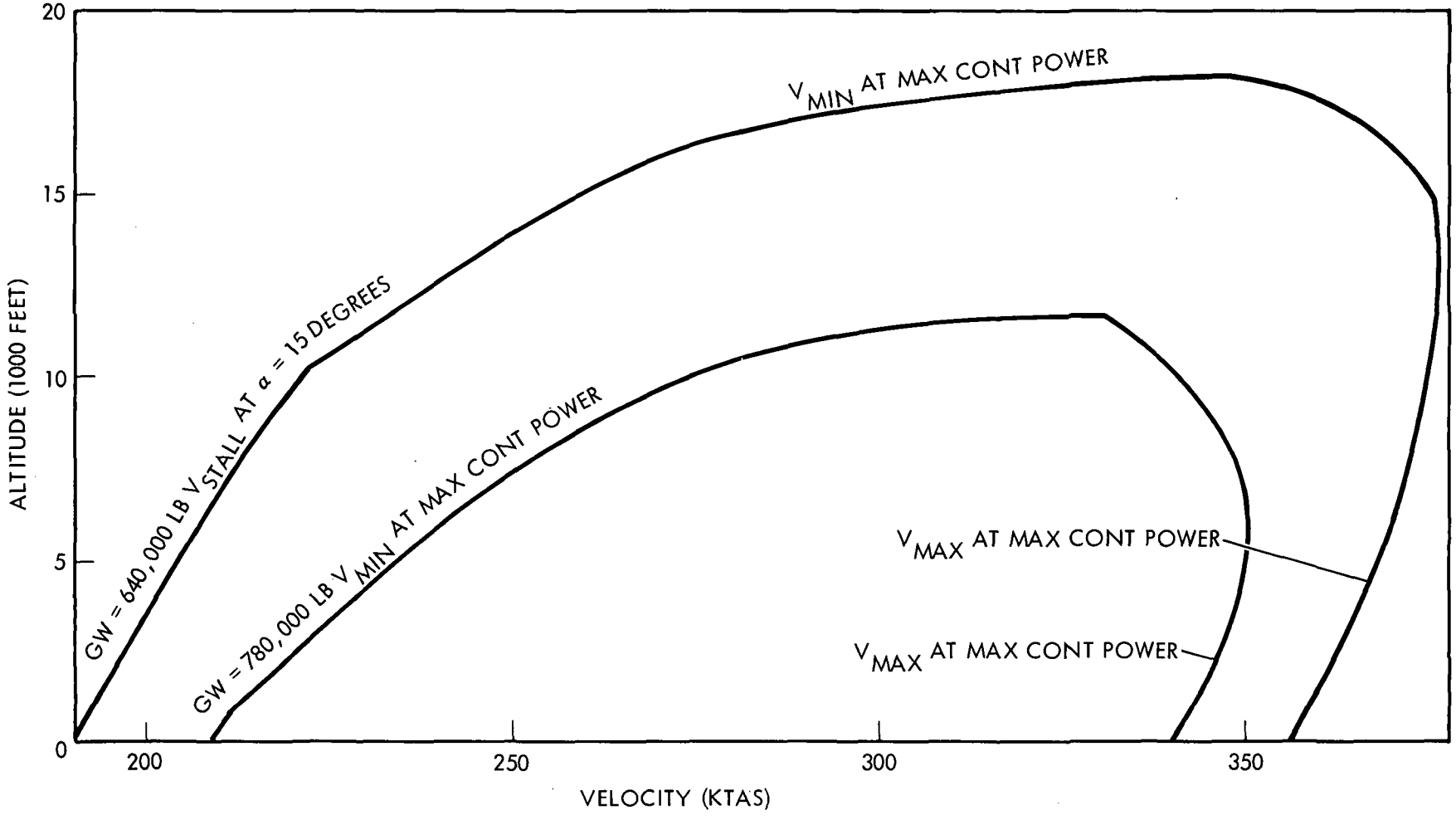

Figure 3.2.1.1.4-2 Performance envelope of velocity vs altitude for cruiseback flight phase

3.2.1.1.6 Approach. During approach, flying qualities shall be as defined in 3.3.8.13.

3.2.1.1.6.1 Communication rates. The CEI shall be capable of providing communications as specified in 3.2.1.1.5.1.

3.2.1.1.7 Landing. The CEI shall be capable of being landed horizontally on a 10,000 foot runway, with crew control, under FAA Category II conditions, in the atmosphere defined in TM-X-53872.

3.2.1.1.7.1 Landing conditions. The landing performance for the design and maximum landing gross weights shall be based on touchdown on a dry concrete runway on a standard day as defined by the 1962 U. S. Standard. The CEI shall be capable of landing ground roll as specified in Table I, at sea level, standard day conditions, with a fuel reserve of 35,000 pounds.

Table I. Takeoff and landing ground roll

Takeoff		Landing	
Weight in lbs	Distance, ft	Weight in lbs	Distance, ft
See 3.2.2.3	TBD	See 3.2.2.3	5,500

3.2.1.1.7.2 Communication rates. The CEI shall be capable of providing communications as described in 3.2.1.1.5.1.

3.2.1.1.8 Waveoff/go-around. The CEI shall be capable of more than one landing attempt in the approach configuration with one air-breathing engine inoperative at a landing site after completing the cruise back flight specified in 3.2.1.1.4.

3.2.1.1.8.1 Communication rates. The CEI shall be capable of providing communications at the same rates and frequencies as specified in 3.2.1.1.5.1.

3.2.1.2 Ferry. The performance specified for this function includes the following phases: takeoff (TO), climb to cruise altitude (CL), cruise (CR), descent (D), approach (PA) and landing (L). The flying qualities shall be as defined in 3.3.8.13.

3.2.1.2.1 Takeoff. The CEI shall be capable of the horizontal takeoff performance stated in 3.2.1.1.7.1 Table I under sea level, standard day conditions. The horizontal takeoff performance shall be based on a balanced field takeoff in which the critical engine is cut at the critical engine failure speed, and the takeoff can be either completed from or aborted on the runway remaining.

3.2.1.2.1.1 Communication rates. Same as 3.2.1.1.5.1.

3.2.1.2.2 Climb to cruise altitude. The CEI shall be capable of climbing at an average rate of 400 feet per minute to cruise altitude specified in paragraph 3.2.1.1.4. Range calculations will take credit for the distance covered during climb.

3.2.1.2.2.1 Communication rates. Same as 3.2.1.1.5.1.

3.2.1.2.3 Ferry cruise range. The CEI shall be capable of a ferry range of at least 300 nautical miles on full internal fuel. The ferry range shall be based on takeoff at sea level, standard day conditions, flight against a 50 knot headwind, with fuel allowances for takeoff and climb, cruising at 10,000 feet altitude, with the loss of one engine at point of no return and on a 20 minute fuel reserve at maximum endurance.

3.2.1.3 Abort

3.2.1.3.1 Prelaunch. Prior to lift off and from the time of decision to abort, the crew shall be able to egress from the vehicle to a platform outside the vehicle in less than 30 seconds.

3.2.1.3.2 Mated ascent. At any point during ascent, the booster shall be capable of releasing a functioning orbiter within 7.0 seconds from an initiate separation signal. Under dire emergency conditions (e.g., imminent explosion necessitating immediate termination of the booster thrust), the booster shall be capable of releasing an inert orbiter within 1.5 seconds and attaining zero thrust within 3.0 seconds of the emergency release signal.

3.2.1.3.2.1 Early separation. The booster shall be capable of a maneuver when mated that allows safe separation. The separation timing shall be a variable within the capability of the loads and controls on both stages as indicated in ICD 2.4.4-11186.

3.2.1.3.2.2 Post separation. Following premature release, the booster shall be capable of continuing along an altered ascent profile until propellants are depleted and subsequent entry and transition and cruise to the launch site or an alternate site. The requirement shall not apply if any particular damage has been sustained by the booster which may have necessitated premature separation.

3.2.1.4 Taxiing. Following landing, and at the termination of ground roll, the CEI shall be capable of taxiing to a designated parking or safing area or being transported with aircraft towing equipment.

3.2.1.5 Useful life. The useful life of the CEI shall be 10 years or 100 missions, whichever occurs first, with normal maintenance and refurbishment. The mission life is equivalent to 450 hours of intermittent usage.

3.2.1.5.1 Utilization rate. The utilization rate shall be 45 flight hours per year per CEI.

3.2.1.6 Prelaunch support performance. During preparation for launch, including erection, transportation to launch pad, and standby prior to lift-off, the CEI shall be capable of achieving the following in accordance with conditions described in the interface documents listed in 3.1.2.

a. Vehicle erection. Vehicle erection shall be accomplished from a horizontal to a near vertical position at an inclination rate of less than 10 degrees per minute.

b. Mated vehicle transportation. Not more than TBD hours shall be required for movement from the mating area to the launch site.

c. Communication. Ground data links shall be provided for assessment of anomaly conditions in the LRU's. The data shall be transmitted at the following rates and frequencies:

Rate TBD Frequency (Hz) TBD

d. Component stabilization time. Not more than 15 minutes shall elapse from ambient temperature to operating temperature.

e. Propellant loading. Propellants shall be loaded simultaneously at the following maximum rates:

Liquid oxygen - 11,500 gpm for not more than 75 minutes

Liquid hydrogen - 23,000 gpm for not more than 75 minutes

Propellants (JP) - 144,000 pounds for not more than 44 minutes

f. Propellant holding. The CEI shall be capable of holding propellants for up to 12 hours without degradation to the propellants.

g. Propellant unloading. The simultaneous unloading of the total tankage of liquid oxygen and liquid hydrogen shall not exceed 4 hours.

h. Pressurizing agents. TBD pounds in not more than 44 minutes.

3.2.1.7 Launch. The CEI shall be capable of providing signals and propellants to the main engines during launch. The thrust rise-rate shall be controlled to 50% of rated thrust and after verification of engine operation and release of holddown. The CEI shall be capable of providing signals and propellants at higher rates and launch into the ascent phase when the thrust-to-weight ratio is greater than one. (See 6.3.2.) The CEI shall be capable of disconnection by its motion from those connections required to return it to a safe condition.

3.2.1.8 Support and post launch performance. Subsequent to launch and prior to preparation for storage or future launch, the CEI shall be capable of the following performance as conditioned by the interface documents listed in 3.1.2.

a. Umbilical disconnects. The umbilical disconnects shall be capable of being disconnected from the ground source connectors at time of lift-off without electrical transients or fluid leakage.

b. Post flight data dump. Using CEI power, data shall be communicated to a ground connection in the safing area within 10 minutes from time of connection to the ground data link connector.

3.2.1.9 Purging time. The CEI shall be capable of being purged while in a safing area within 60 minutes. This time includes verification that the concentration of propellants is within the limits specified in 3.3.1.1 herein.

3.2.2 Physical characteristics

3.2.2.1 Engines. The main engines shall be as defined in CEI specification for the engine. See Section 2.

3.2.2.2 Dimension and cube limitations. The overall dimensions and volumes of the CEI shall not exceed those given in Figures 3.2.2.2.2-1, 3.2.2.2-2 and 3.2.2.2-3.

3.2.2.3 Weight. The definitions for the weight terms specified in Table II shall be those specified in paragraph 6.3 herein. The weights given were allocated in accordance with the functional coding given in MIL-M-38310 as modified by NASA. The weights shown are for reference only. For detail weights see the weights statement.

Table II. Weights

Condition	Weight (lb)
1. Launch Gross Weight	4,188,223
2. Entry Condition	805,916
3. Start Cruise	786,845
4. Landing	678,583
5. *Ferry Takeoff	781,388
*Excludes special ferry equipments	

3.2.2.4 Strength and rigidity. The strength and rigidity of the CEI shall be in compliance with MIL-M-8856 as implemented by SP 8057 except as specified herein.

3.2.2.4.1 Structural criteria. The structural design criteria to be applied to the CEI shall be those contained in the following specifications unless otherwise specified herein: MIL-A-8860, MIL-A-8861, MIL-A-8862, MIL-A-8865, and MIL-A-8867.

3.2.2.4.2 Design loading. The CEI shall be capable of supporting a vertical, unfueled, unmanned orbiter with payload and located (relative to the CEI) as shown in ICD SR 2.4.4-11186 booster-orbiter interface control document for erection and transport. The CEI shall be capable of supporting the vertical, fueled, manned orbiter during the launch flight and separation, and be capable of withstanding the propulsion forces and internal pressures throughout this regime.

3.2.2.4.3 Maneuvering flight factors. The CEI shall be designed to class C load factor requirements specified in Table I of MIL-A-8861.

3.2.2.4.4 Landing and ground handling. The landing and ground handling design criteria for the CEI shall be in compliance with MIL-A-8862 except as otherwise specified herein.

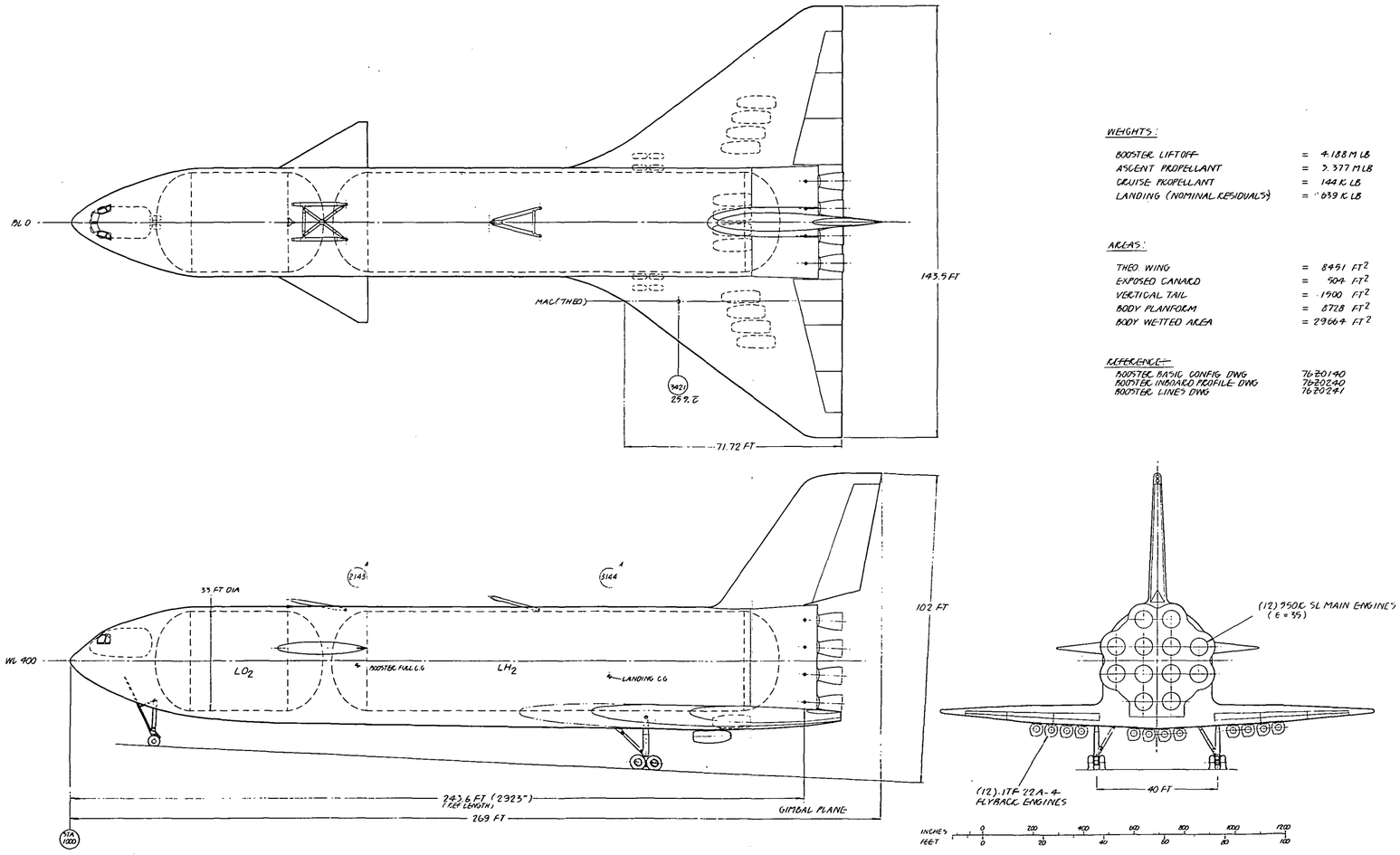

Figure 3.2.2.2-1 Three view of B-9U

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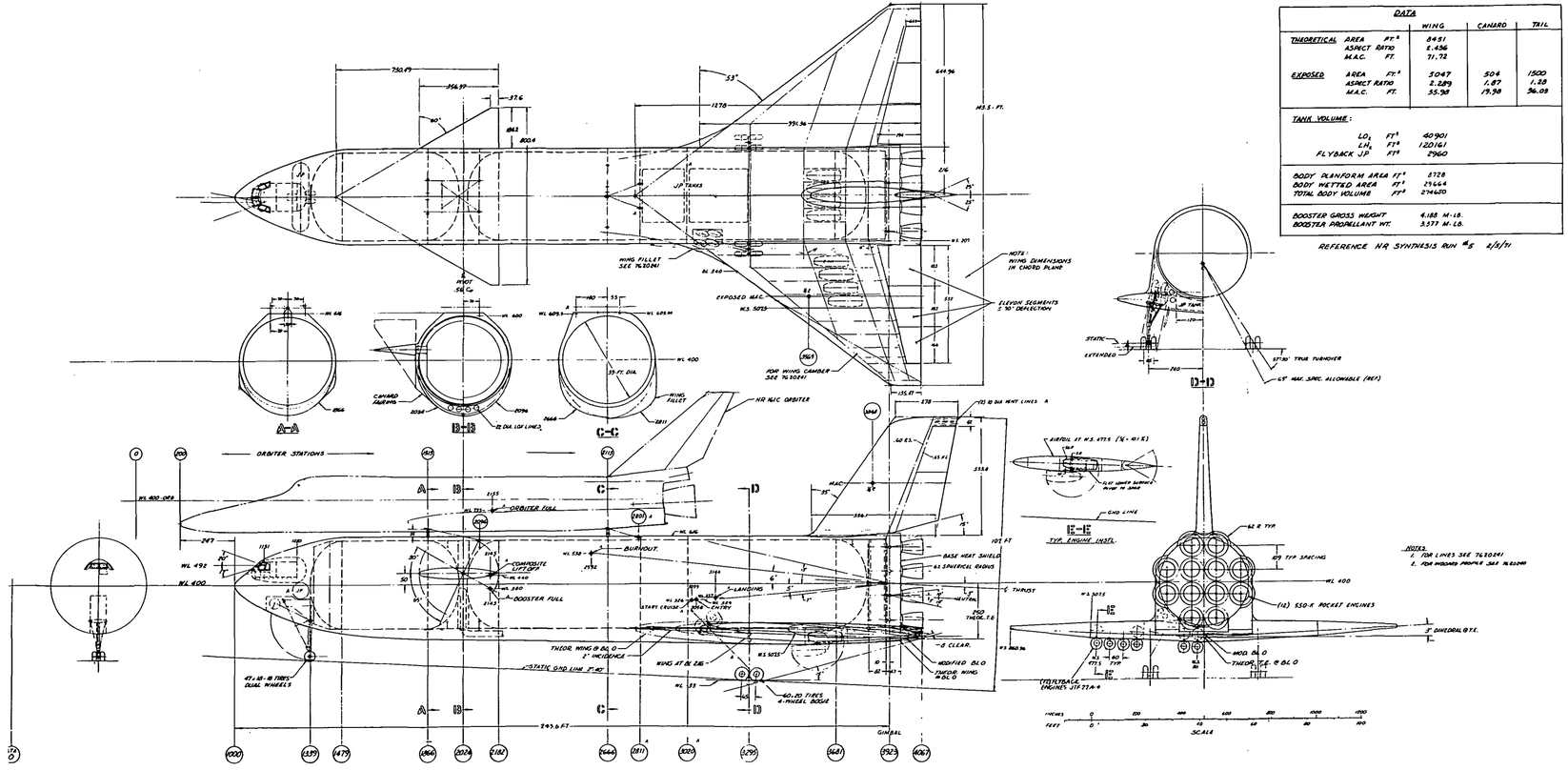

Figure 3.2.2.2-2 Basic configuration of B-9U

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LEGEND

1. Pilot Seats
2. Instrument Panel
3. Consoles
4. Overhead Panel
5. Crew Module
6. Crew Module Support
7. Avionics Equipment Racks
8. Nose Gear Wheel Well
9. Crew Access Hatches
10. Retractable Heat Shield
11. Nose Structure
12. Nose Gear Support Bulkhead
13. TPS Support Lines
14. Main LO_2 Tank Structure
15. LO_2 Tank Frame
16. Orbiter Mechanism Support Bulkhead
17. Nose Landing Gear Doors
18. Nose Landing Gear Assembly
19. Nose Gear Support Structure
20. TPS Support Structure
21. Canard Structure Assembly
22. Canard Actuators
23. Forward Orbiter Attachment Mechanism
24. Orbiter Mechanism Attachment Fittings
25. Orbiter Mechanism Attachment Fitting
26. Orbiter Mechanism Support Bulkhead
27. Aft Orbiter Attachment Mechanism
28. Orbiter Mechanism Attachment Fittings
29. Orbiter Mechanism Attachment Fitting
30. Orbiter Mechanism Support Bulkhead
31. Orbiter Mechanism Support Bulkhead
32. Main Hydrogen Tank Structure
33. Main Landing Gear Support Bulkheads
34. Main Landing Gear Assembly
35. Main Landing Gear Doors
36. Landing Gear Drag Load Structural Link
37. Wing Drag Load Structural Link
38. Wing Body Vertical Attach Links
39. Wing Body Side Load Attach Link
40. Wing Structure Assembly
41. Vertical Tail Structure Assembly
42. Vertical Tail Attach Fittings
43. Thrust Structure Assembly
44. Base Heat Shield Assembly
45. Pad Hold-Down & Support Fittings
46. Main Rocket Engines
47. Air Breathing Engine Pods
48. Engine Deployment Power Hinge
49. JP Fuel Tanks
50. JP Fuel Distribution System
51. JP Fuel Refuel Fitting (Level Attitude)
52. JP Fuel Vent Line to Wing Tip
53. JP Fuel Rise-Off Disconnect
54. Main LO_2 Tank Vent Line
55. LO_2 Tank Pressurization Line
56. Main LO_2 Feed Lines
57. Main LO_2 Distribution System
58. Main LO_2 Fill/Drain Line
59. Gas Exhaust Line
60. Main Hydrogen Tank Vent Line
61. Hydrogen Tank Pressurization Line
62. Main LH_2 Distribution System
63. Main LH_2 Fill/Drain Line
64. Main LH_2 Vent
65. Gas Exhaust Vent
66. Purge Nitrogen On-Pad Disconnect
67. Aft Nitrogen Purge Rings
68. Purge Nitrogen To Hydrogen Tank
69. Forward Nitrogen Purge Ring
70. Air Cycle Refrigeration System (2)
71. Refrigeration Lines to Crew Module
72. APS LO_2 Storage Supply
73. APS LH_2 Storage Supply
74. APS LO_2 Fill/Drain Line (On-Pad)
75. APS LO_2 Fill/Drain Fitting (Level Attitude)
76. APS LH_2 Fill/Drain Line (On-Pad)
77. APS LH_2 Fill/Drain Line (Level Attitude)
78. APS LO_2 Heat Exchanger (3)
79. APS LO_2 Turbopumps (3)
80. APS LH_2 Heat Exchanger (3)
81. APS LH_2 Turbopumps (3)
82. APS GO_2 Accumulator
83. APS GH_2 Accumulator
84. APS LO_2 Storage Tank Vent Line
85. APS LH_2 Storage Tank Vent Line
86. APS GO_2 Distribution Line
87. APS GH_2 Distribution Line
88. Auxiliary Power Unit (4)
89. APU Exhaust Lines
90. APS Thrusters - (4) Fwd. Pitch
91. APS Thrusters - (8) LH Fwd. Yaw
92. APS Thrusters - (8) RH Fwd. Yaw
93. APS Thrusters - (5) LH Aft Pitch-Roll
94. APS Thrusters - (5) RH Aft Pitch-Roll
95. GHe Storage Supply
96. Helium Fill/Drain Disconnect
97. APU Avionics Racks
98. Aft Avionics Racks
99. Vehicle On-Pad Power Connection
100. ECS On-Pad Connection
101. Maintenance Access Door
102. Rudder Acuators (4)
103. On-Pad Sway Brace Attachment
104. Jack Points
105. APS GO_2 Ground Charge
106. APS GH_2 Ground Charge

Figure 3.2.2.2-3 Inboard profile of B-9U

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3.2.2.4.5 Flutter, divergence, and aerostability. The flutter, divergence, and aerostability criteria shall be in compliance with MIL-A-8870 except as otherwise specified herein.

3.2.2.4.6 Windshield design. The windshield shall be designed to withstand the impact of a bird weighing TBD at Mach TBD, and the reentry requirements specified herein.

3.2.2.5 Safety

3.2.2.5.1 Cockpit station. The CEI shall accommodate a command pilot and a pilot and shall be operable by a single pilot from either seat, under emergency conditions. A shirt sleeve environment shall be provided so that the crew can perform tasks with no greater encombrances than a lightweight flying suit, underwear, gloves, and boots. The cockpit geometry shall be in compliance with MIL-STD-1333.

3.2.2.5.2 Visibility. External vision fields shall be provided the crew in accordance with Figure 3.2.2.5.2-1.

3.2.2.5.3 Cockpit ingress/egress. The cockpit ingress/egress shall be through outward opening doors. Such doors shall be large enough to permit access for the fifth through ninety-fifth percentile man defined in AFSC DH2-2 and MIL-STD-1472 while the CEI is in either a horizontal or vertical position.

The arrangement of the cockpit shall be such that ingress/egress can be accomplished without inadvertent actuation of switches or entanglement with, or damage to, any controls.

3.2.2.5.4 Emergency escape. Emergency means shall be provided to permit both crew members to evacuate the vehicle in not more than 30 seconds. Zero time shall commence with the crew members fully restrained, as required for launch, with hatches closed and secured for flight.

3.2.2.5.5 Propellant depletion. The booster shall be capable of depleting the main rocket engine propellants except normal residuals prior to landing.

3.2.2.5.5.1 Purge safing. After landing propellant tanks, including propellant ducts and interfacing components in the CEI, shall be capable of being purged with either dry GN_2 or He to within the levels of safety specified herein except prior to loading of propellants when all GN_2 contained inside the LH_2 tank must be purged with GH_2 or He. The design of systems and equipment utilizing LH_2 shall be such that pockets or dead-end purging shall not result in localized concentrations of hydrogen gas larger than that existing in the rest of the system. Systems and equipment being purged shall be declared safe when the exhausted purging gas is less than 3 percent hydrogen by volume. The purging of these systems shall be accomplished in one hour or less.

3.2.2.5.6 Venting provisions. Provisions shall be made for venting from propellant tanks and structures during safing.

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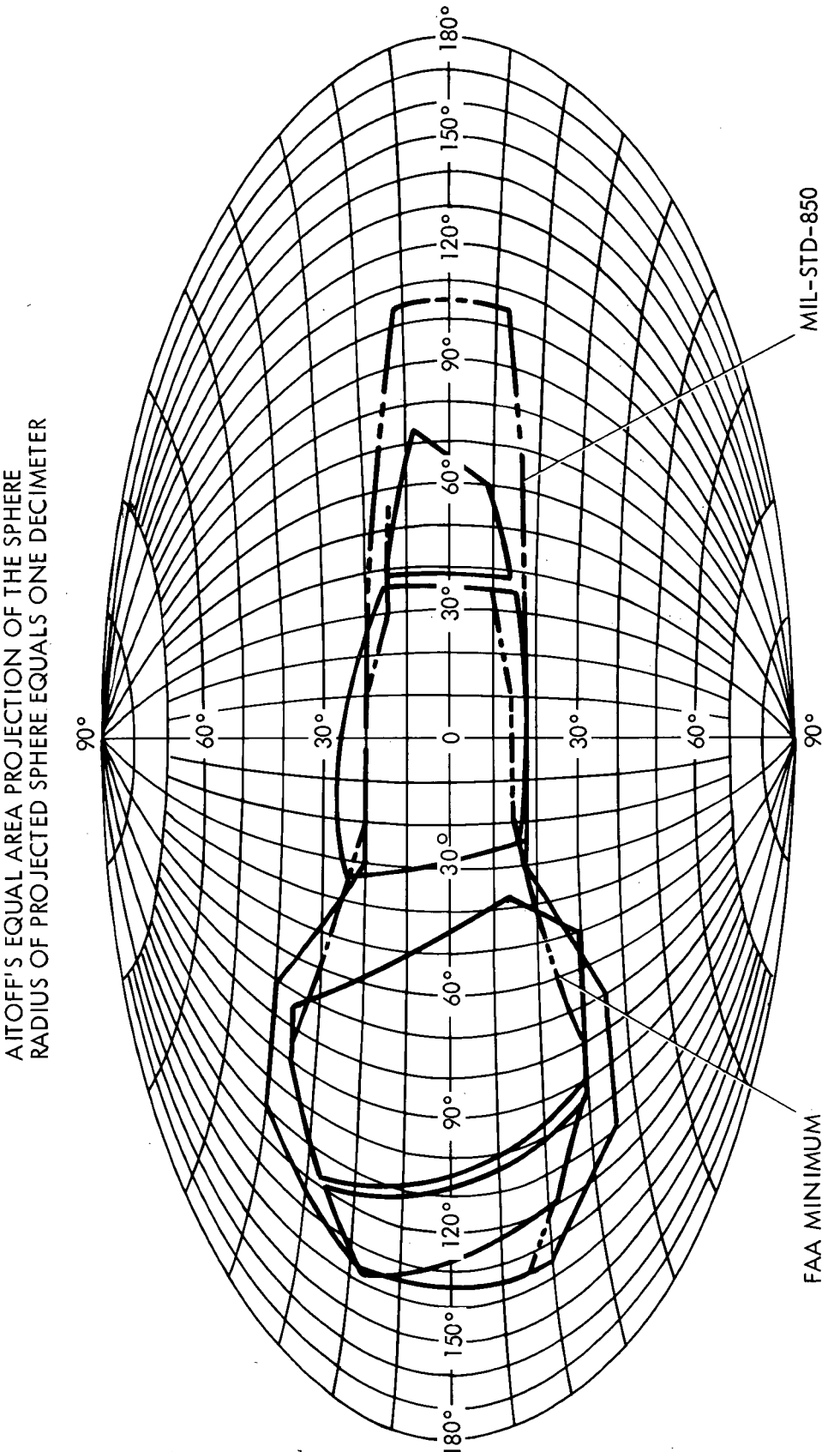


Figure 3.2.2.5.2-1 External visibility field

3.2.2.6 Maintenance access. See 3.2.4.

3.2.2.7 Storage. TBD

3.2.2.8 Jacking, handling, and mooring provisions

3.2.2.8.1 Jacking. Structural provisions shall be incorporated to permit the installation of jacking pads on the structure that will support the weight of the CEI. The CEI shall be capable of being jacked to a height sufficient to clear the landing gear, and leveled in 15 minutes or less.

3.2.2.8.2 Handling. The structure shall be designed to accomodate hard points or attachments to permit the lifting and towing of the CEI. Provisions for suspending the CEI in a vertical position through the longitudinal axis, from not more than two cables without the need for hold-on fixtures, to achieve stability, will be provided.

3.2.2.8.3 Mooring. TBD

3.2.2.9 Holddown provisions. TBD

3.2.3 Reliability

3.2.3.1 Reliability requirements. The reliability design criteria of paragraph 3.2.3 of specification SS 613M0001 shall be used as design standards for all CEI designs with the following exceptions and additions:

a. Paragraph 3.2.3 (c) shall read: Space shuttle safe return capability shall be maintained following any two failures in a subsystem. The vehicle system is in a safe condition if flight personnel/passenger safety is not jeopardized and the vehicle(s) can be returned and landed essentially intact.

b. The criteria contained in applicable parts of MSCM 8080 shall be used as design standards for the CEI design and all deviations from these standards shall be justified and documented.

3.2.3.2 Reliability analysis assumptions. The conditions under which the requirements of paragraph 3.2.3.1 shall be met are:

a. The design reference mission defined in paragraph 3.2.1.1 shall apply.

b. The ground rules for performing reliability comparative numerical estimates as defined in TBD shall apply.

3.2.3.3 Success/failure criteria. The booster must be launched within the predetermined launch window; inject the orbiter into its preselected flight path, reenter, and decelerate to subsonic velocity; fly to a preselected or alternate landing site; and land. Accomplishment of the above constitute design reference mission success. Failure shall be defined as the inability to meet the performance requirements of the mission with the limits delineated in paragraph 3.2.1.1.

3.2.4 Maintainability. The booster shall conform to the maintainability requirements of paragraph 3.2.4 and 3.2.4.1 of specification SS613M0001.

3.2.4.1 Maintainability requirements. Maintainability characteristics of the booster vehicle shall be such that the maintenance and refurbishment portion of the turnaround for the mature operational system shall be not more than, using the 95th percentile man, 5.5 two-shift working days and 4000 maintenance manhours.

3.2.4.1.1 Accessibility for maintenance. Access provisions shall be readily useable with the booster either horizontal or vertical; however, access to the air-breathing engines and the landing gear, and those provided for inspection of airframe/structural areas are specifically exempted from the requirement for use in the vertical position. Conversely, special attention shall be given to access in the vertical position for the avionics compartment, the inter-tank space, the APU compartments, and the power head area of the rocket engines. Access covers to these four areas shall not require more than four minutes for two men using power tools to gain access, and close up must be possible in not more than five minutes.

3.2.4.1.2 Access openings. All maintenance access openings shall conform to the human engineering criteria as expressed in MIL-STD-1472 with respect to size, shape, and suitability for use as "see-through," "reach-through," or "pass-through" provisions.

3.2.4.1.3 Maintainability design features. The design of the CEI shall incorporate the following maintainability design features:

a. Provide quick-opening access to horizontal flight servicing points.

b. Hold to a minimum the number of different types of fasteners used to secure access panels, doors, plates, and covers throughout the booster.

c. Access door or panel seals shall be affixed to the door or panel and not to the fixed structure. Such seals shall be replaceable using standard hand tools.

d. Provide inspection access and/or permanently installed sensors in basic structure critical stress areas.

3.2.4.2 Maintenance and repair cycles. The booster normal ground turnaround will be accomplished within a 14-calendar-day period. Booster ground turnaround maintenance operations will be accomplished within 5.5 days (95th percentile). Elapsed time required for incorporation of major modifications and accomplishment of major structural repair or test is specifically excluded from this requirement.

3.2.4.3 Unscheduled maintenance. TBD

3.2.4.4 Scheduled and periodic maintenance. TBD

3.2.4.5 Major overhaul. The CEI shall be designed to provide the performance and service life specified herein without a planned major overhaul. The intent of planned major overhaul shall be achieved by incremental replacement and repairs accomplished during each turnaround.

3.2.4.5.1 Line replaceable units. Line replaceable units will be subject to the establishment of overhaul intervals consistent with design requirements, safety, and reliability considerations.

3.2.5 Environmental conditions

3.2.5.1 Natural environments. The natural environmental conditions expected to be encountered by the booster during storage, shipment, and operations shall be as given in NASA Technical Memoranda TM-X-53872 and TM-X-53957, and Specification SS613M0001, paragraph 3.2.7.1.

3.2.5.2 Induced environments. The booster shall be designed to withstand the induced environmental criteria specified in paragraphs 3.2.7.2.1 and 3.2.7.2.3.1 of Specification SS613M0001 and as specified herein.

3.2.5.2.1 Aerothermodynamic (external). The external aerothermodynamic environment (EAE) shall be that defined in four flight segments corresponding to mated ascent, staging, entry/transition, and flyback. Natural environments from paragraph 3.2.5.1 are used in defining the EAE. The EAE shall be composed of aerodynamic heating, booster main propulsion system plume heating, ACPS plume heating, orbiter plume impingement heating, and ABES exhaust heating. The EAE is expressed as heat transfer rate profiles for each flight segment of the baseline mission. Each profile is considering a 3σ trajectory, factors of safety on the heating rates, and in the case of base heating main propulsion system engines out (see Figures 3.2.5.2.1-1 through 3.2.5.2-9). NASA SP-8029 is used in the EAE definition.

3.2.6 Transportability. Except as specified below, all components of the booster shall be suitable for air or surface modes of transportation. Because of size, the following components cannot be transported by existing available aircraft:

Fuselage, wings and empennage assembly.

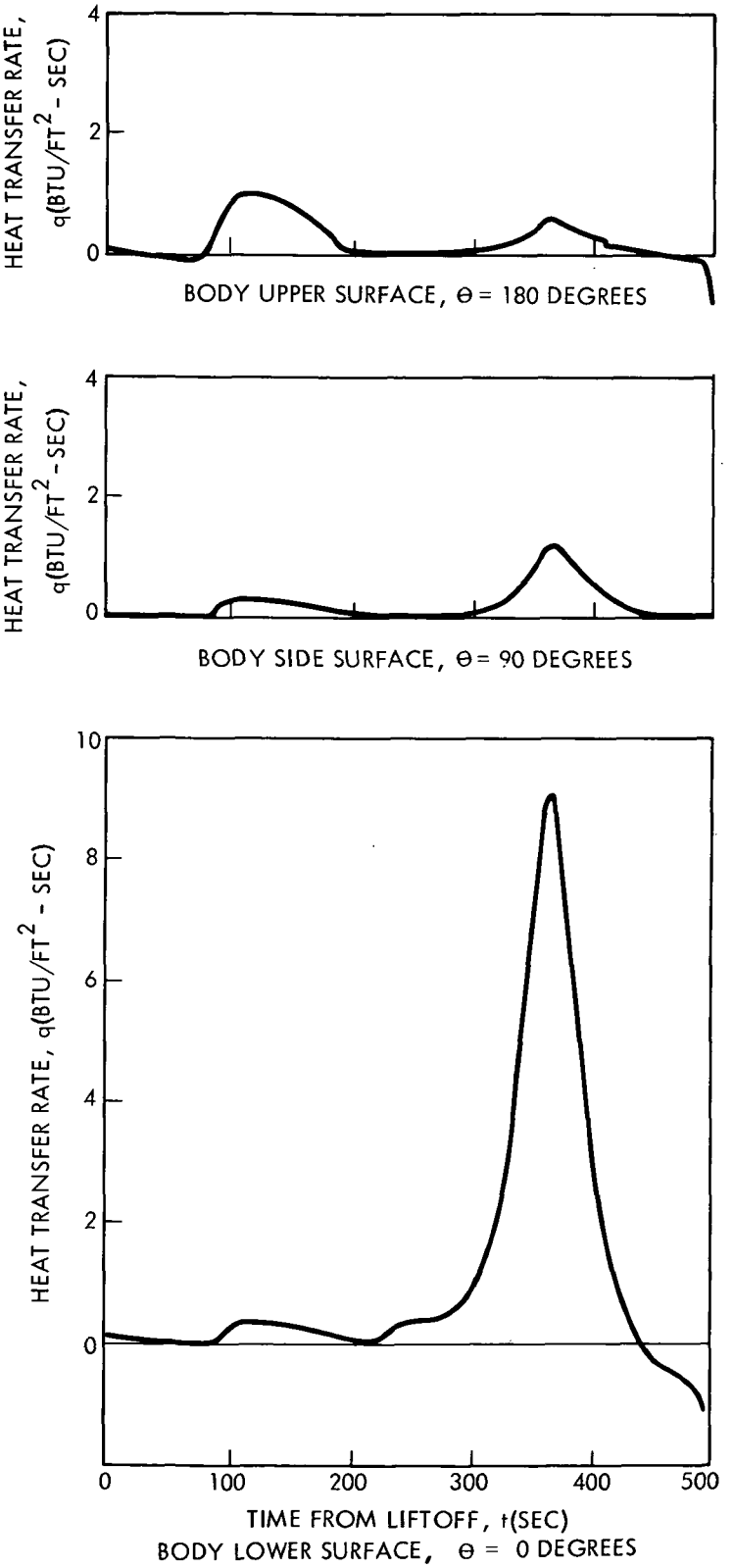
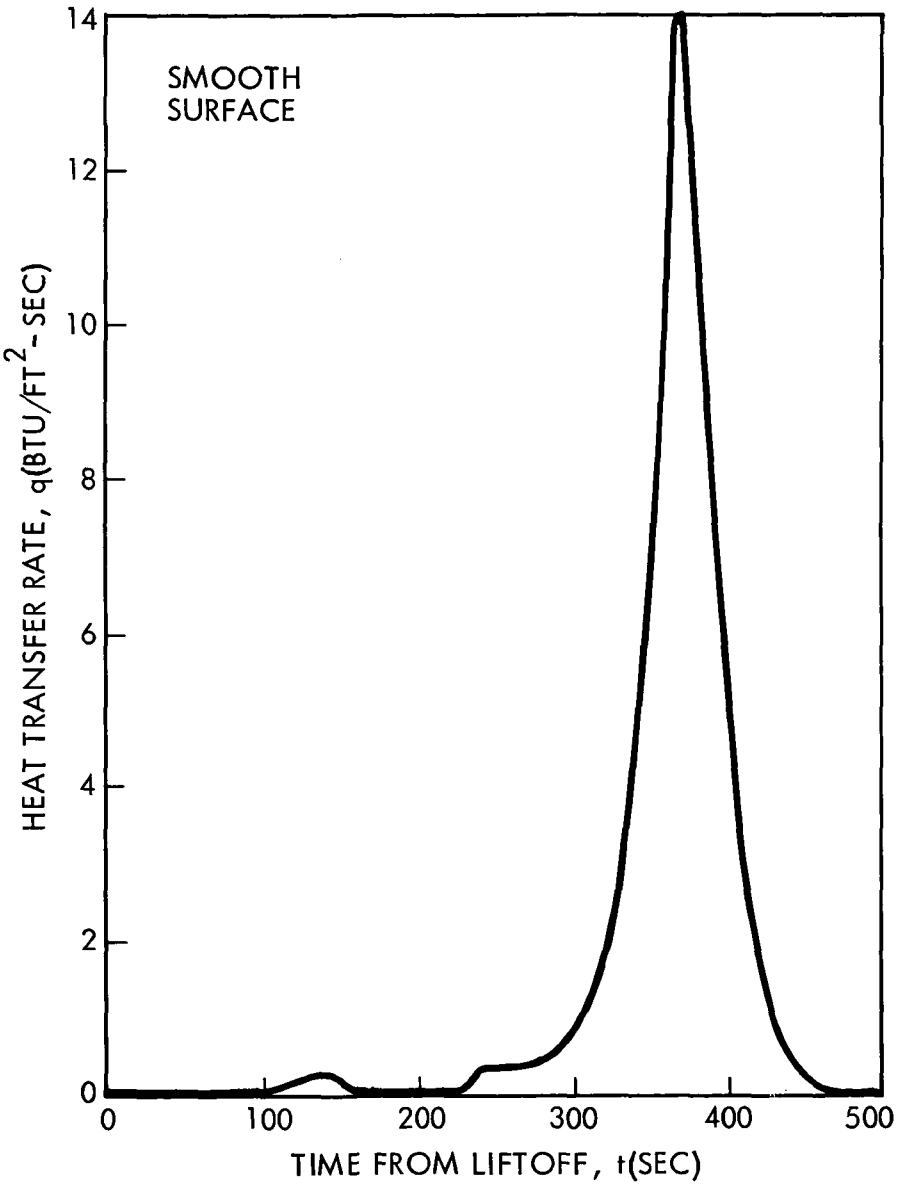
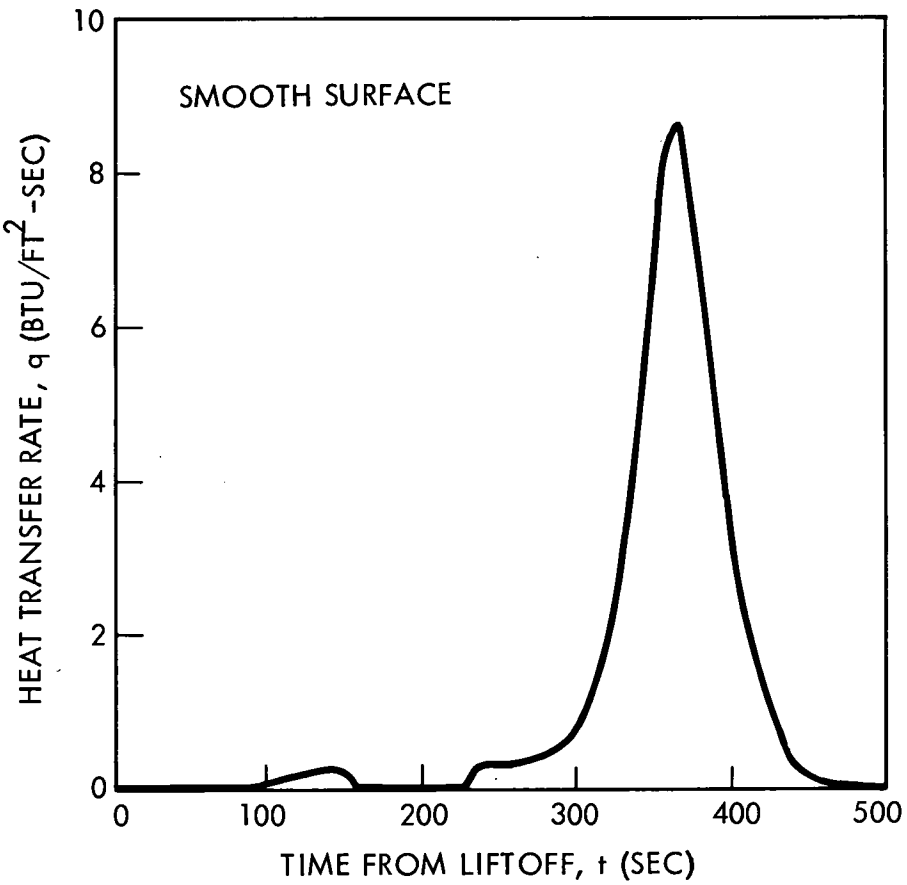


Figure 3.2.5.2.1-1. Fuselage heating rate histories at station 2400 versus peripheral location



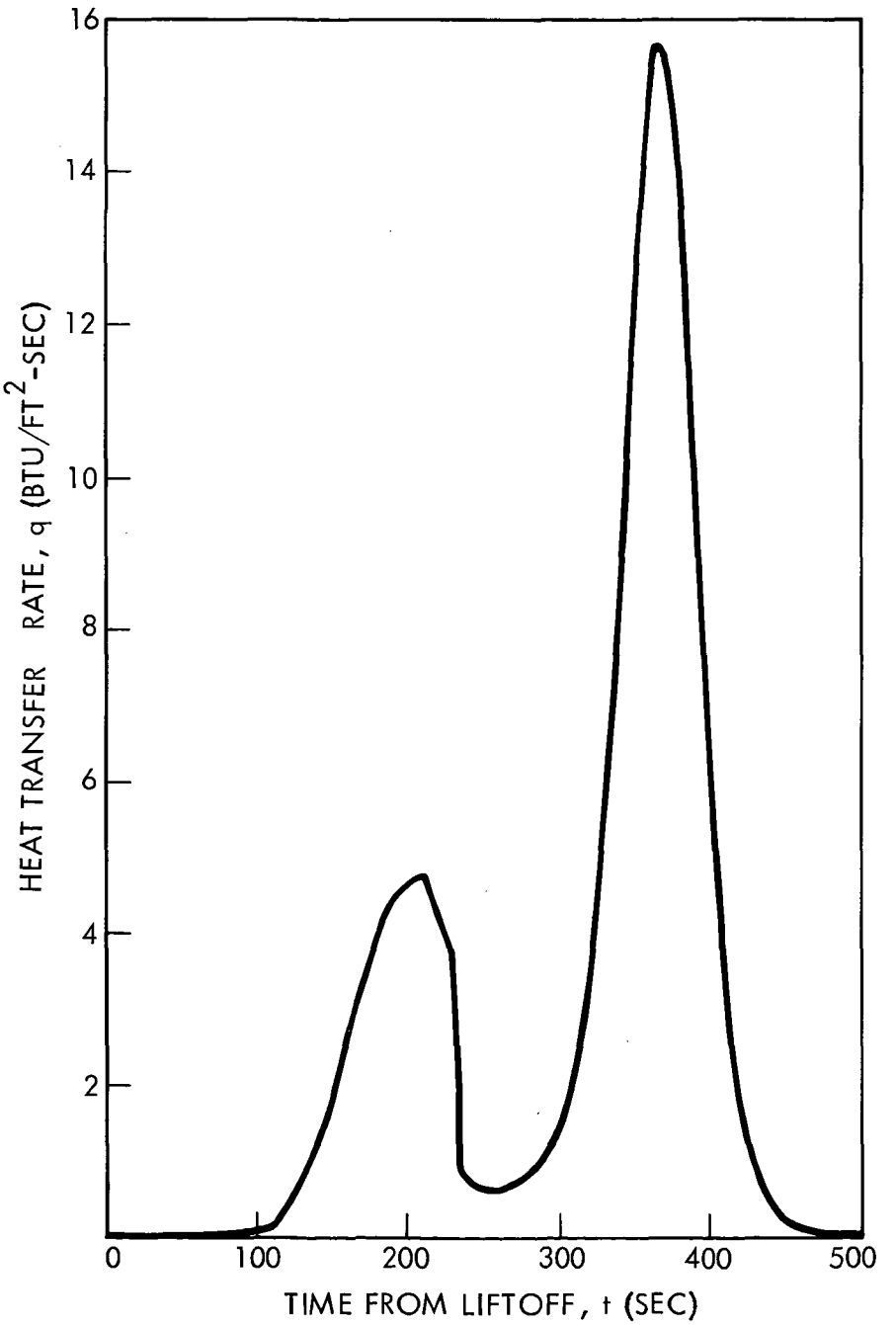
(a) LOWER SURFACE 35% SPAN 40% CHORD

Figure 3.2.5.2.1-2. Heating rate histories at typical locations on wing (sheet 1 of 3)



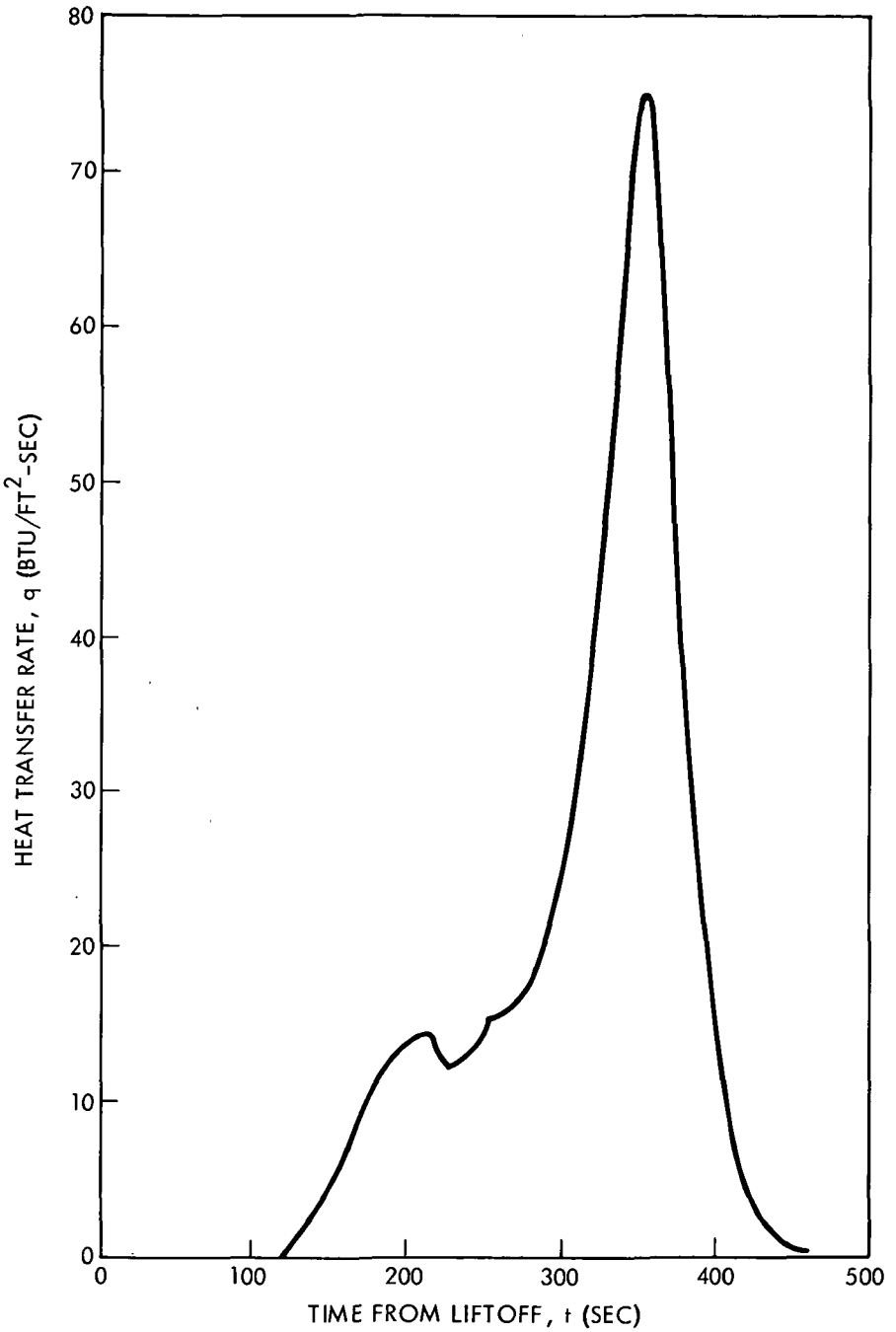
(b) LOWER SURFACE INBOARD AND OUTBOARD 50% CHORD

Figure 3.2.5.2.1-2. Heating rate histories at typical locations on wing (sheet 2 of 3)



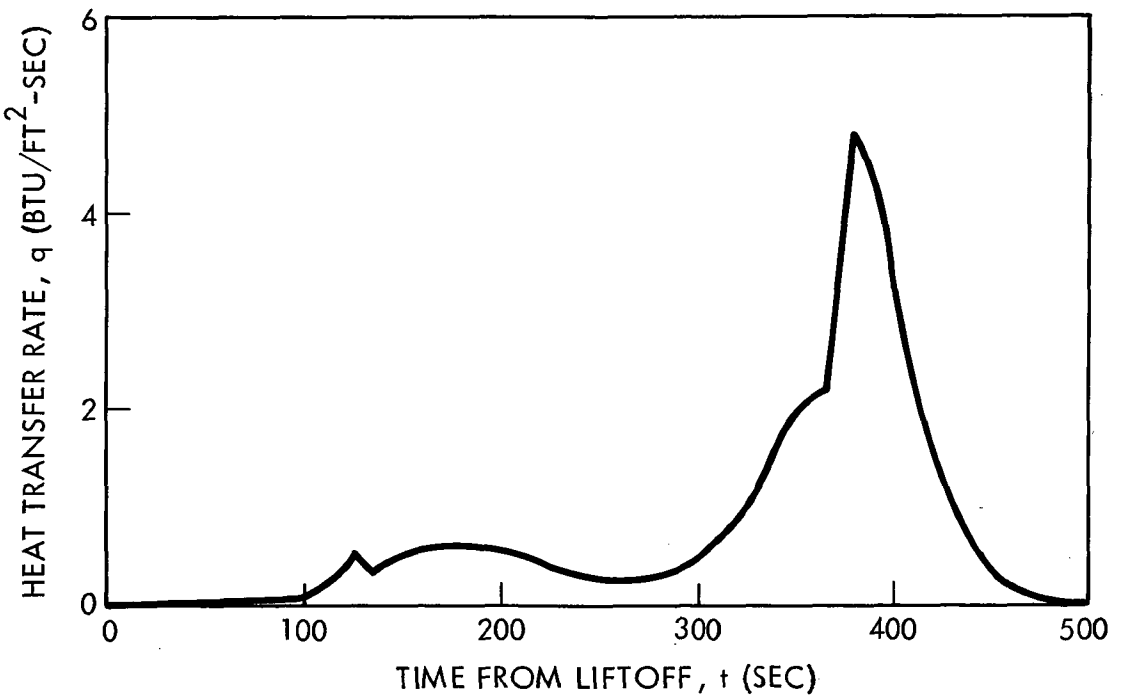
(c) LEADING EDGE INBOARD

Figure 3.2.5.2.1-2. Heating rate histories at typical locations on wing (sheet 3 of 3)



(a) LEADING EDGE

Figure 3.2.5.2.1-3. Heating rate histories at typical locations on canard (sheet 1 of 2)



(b) UPPER AND LOWER SURFACE 75% SPAN 70% CHORD

Figure 3.2.5.2.1-3. Heating rate histories at typical locations on canard (sheet 2 of 2)

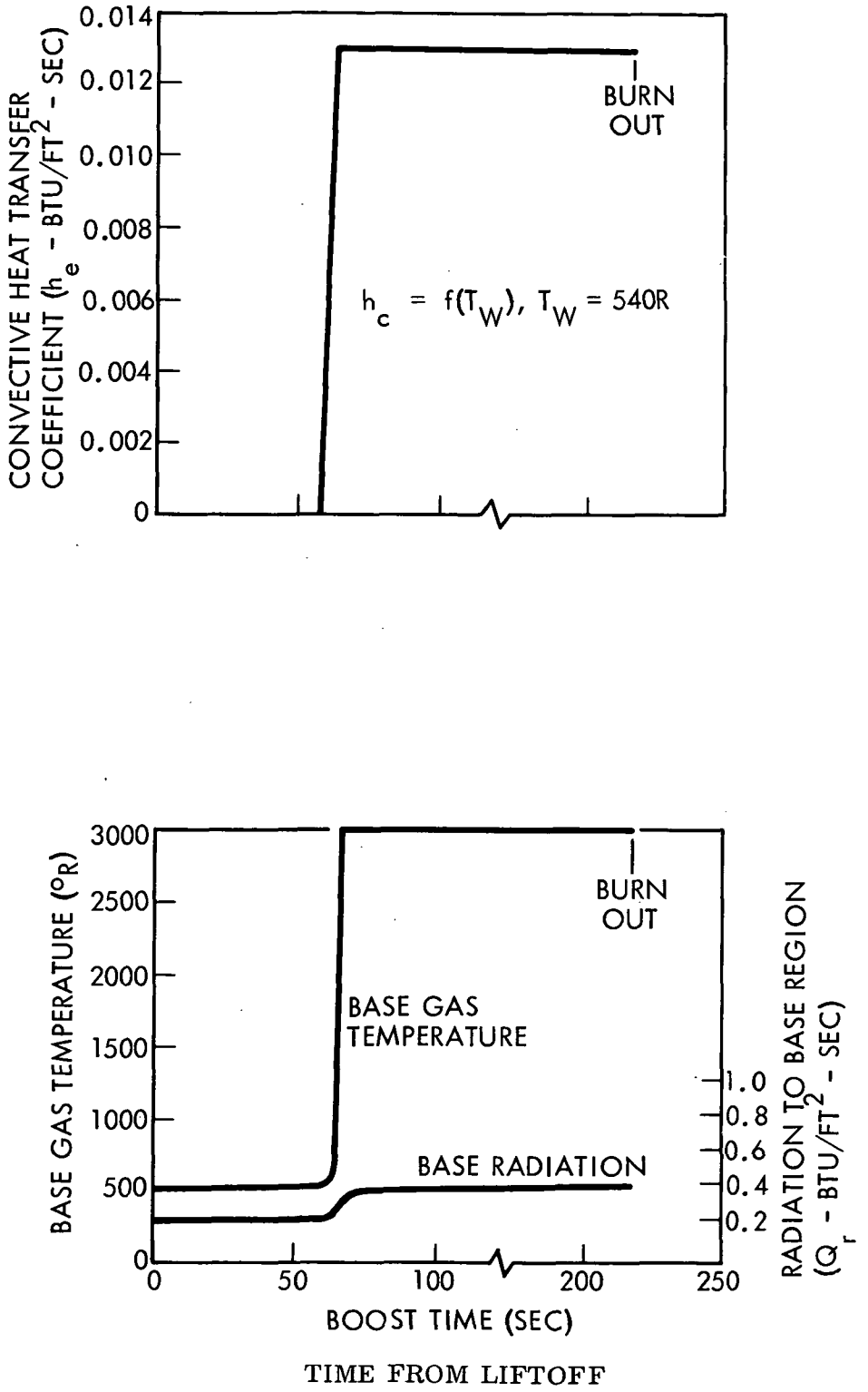


Figure 3.2.5.2.1-4. Booster base region thermal environment parameters

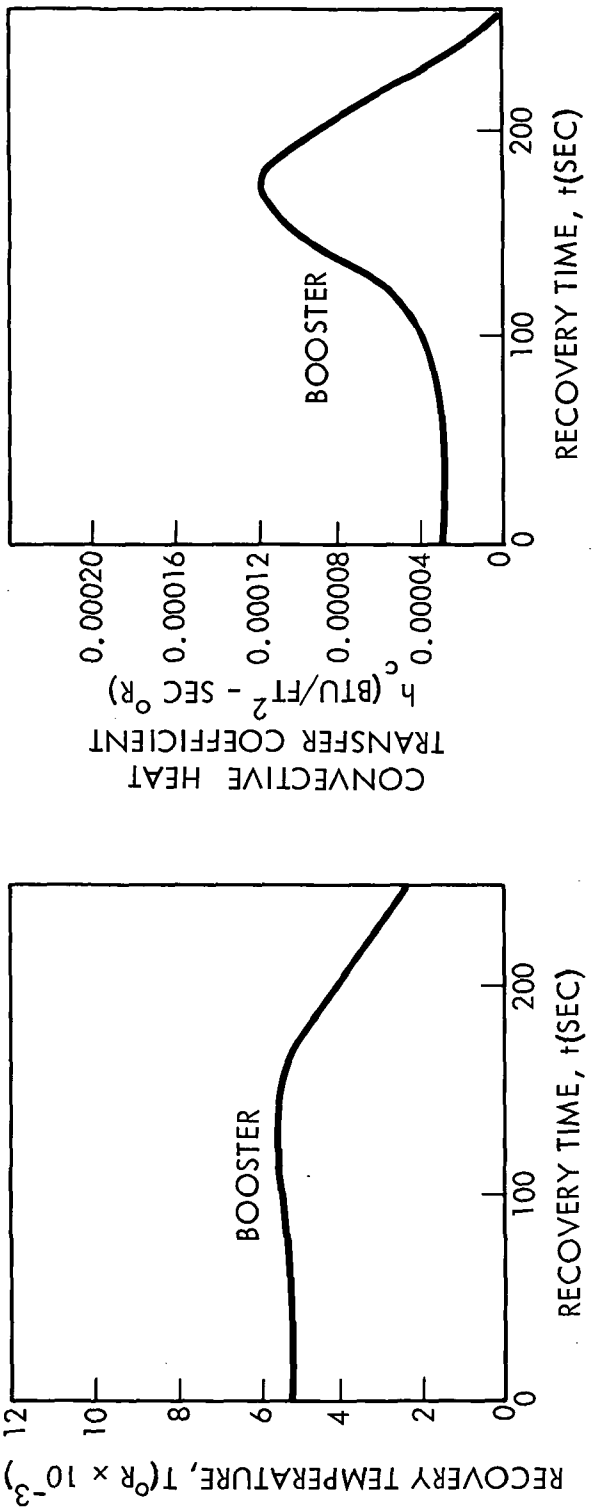


Figure 3.2.5.2.1-5. Base recovery temperature and heat transfer coefficient

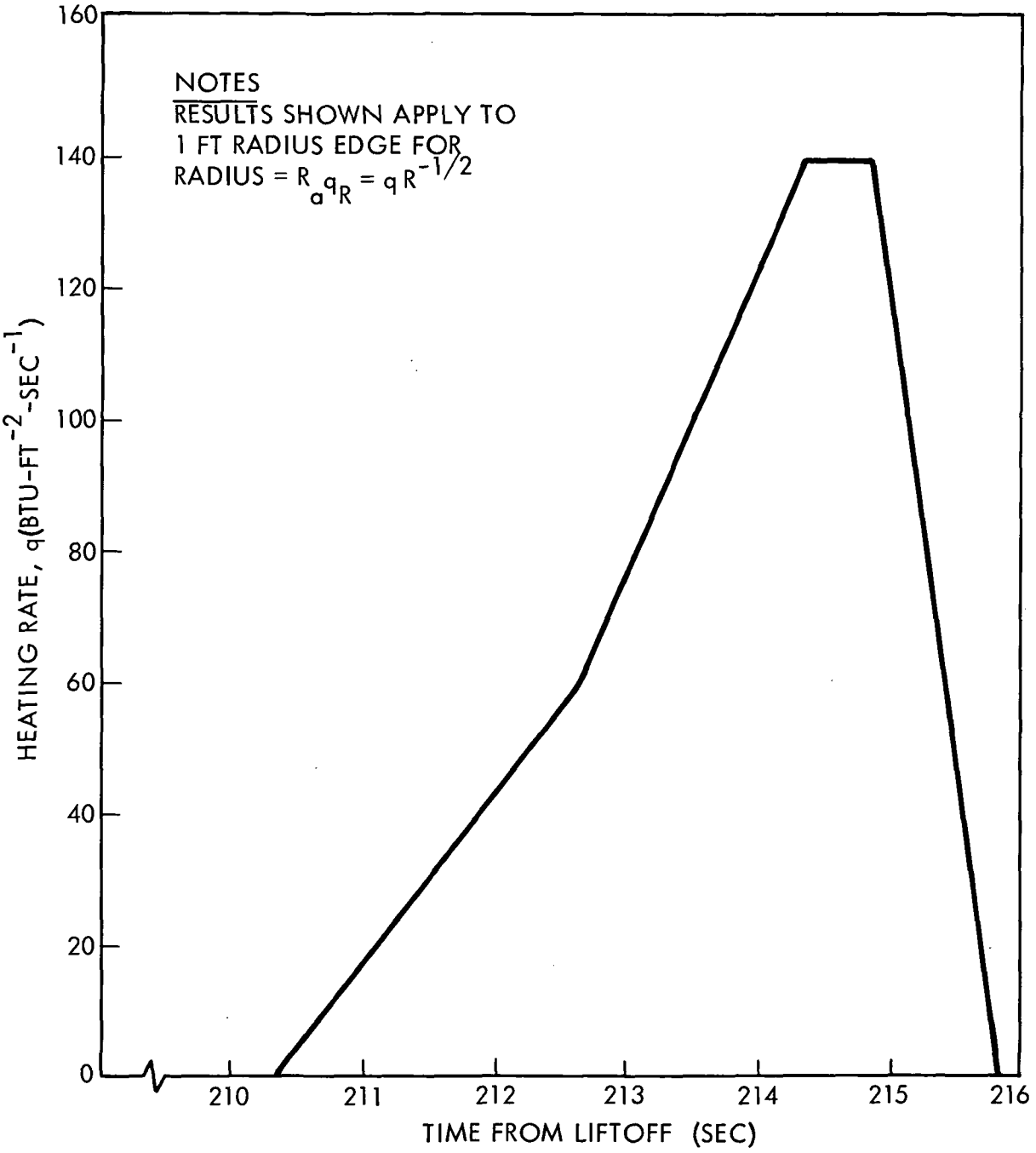


Figure 3.2.5.2.1-6. Heat input to vertical fin leading edge due to plume heating from orbiter (reverse link)

3.3 Design and construction. The standard axes coordinate system shall be as specified in TM-X-53973.

3.3.1 Materials, parts, and processes. Materials, parts, and processes shall conform to the requirements specified in paragraphs 3.3.1, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.2.4, 3.3.2.5, 3.3.2.6, 3.3.2.7, and 3.3.2.8 of the system specification SS613M0001. MSFC 85M03928 and the preferred parts list MSFC 85M03929 shall aid in the selection of parts.

3.3.1.1 Cleanliness and contamination limits. Cleanliness and contamination limits for main engine components shall be within the limits specified in Table III.

3.3.2 Electromagnetic compatibility. Components and systems within the CEI shall be designed for electromagnetic compatibility in accordance with applicable portions of the requirements of paragraphs 3.3.1.11 and 3.3.1.11.1 of specification SS613M0001.

3.3.3 Nameplates and product marking. Nameplates and product marking shall be in compliance with the requirements of paragraph 3.3.1.12 of specification SS613M0001, except that equipment, assemblies, and parts shall be marked for identification in accordance with NHB 8040.2 Exhibit 10.

3.3.3.1 Lot markings. Where control of individual articles or lots of articles or materials is required, one or more of the following detailed identification methods shall also be used, as applicable:

a. Date codes. Date codes indicating date of manufacture to identify articles or materials made by a continuous and controlled process and those that are subject to variations or degradation with age.

b. Lot numbers. Lot numbers to identify articles or materials produced in homogeneous groups and where unique data are not required to be related to individual items. Heat, billet, or batch numbers are included in this category.

c. Serial numbers. Serial numbers to identify individual materials or articles for which unique data are to be maintained or when other reasons exist for individual control.

3.3.4 Workmanship. Workmanship shall be in compliance with the requirements of 3.3.1.10 of specification SS613M0001. The workmanship displayed in fabrication and assembly of the CEI assemblies shall be such as to assure, within design limitations, ability of the CEI assemblies to meet their performance requirements under all applicable environmental conditions. Unauthorized repair, welding, loose rivets, heavy burrs, indiscrimate placement of fasteners, and parts assembled by introduction of high stresses not prescribed in design are typical signs of inferior

Table III. Engine Operating Fluid Cleanliness Limits

Type	Maximum Particle Size, or Requirement (1)		Remarks
	Particle Size (x), Microns	Particles Allowable (No.)	
GN_2, (2) MIL-P-27401	$x \leq 30$ $30 < x \leq 100$ $x > 100$	No limit 25 0	
Helium, (2) MSFC-SPEC -364 or MIL-P-27407	$x \leq 30$ $30 < x \leq 100$ $x > 100$	No limit 25 0	
Liquid Oxygen (3) MIL-P-25508	$x \leq 100$ $100 < x \leq 200$ $200 < x \leq 250$ $x > 250$	No limit 1000 500 0	Acetylene content shall be no larger than 1.55 ppm, soluble hydrocarbon shall not exceed 75 ppm, the purity not to be less than 99.2 percent, and the particulate content of the oxygen must not be limited by the total weight.
Liquid Hydrogen, (3) MIL-P-27201	$x \leq 100$ $100 < x \leq 200$ $200 < x \leq 250$ $x > 250$	No limit 1000 500 0	
Hydraulic Fluid MIL-H-5606	Values specified in MSFC-PROC-166	Values specified in MSFC-PROC-166	

NOTES:

1 Cleanliness limits specified are the maximum allowable at the engine-to-vehicle interface.

2 Maximum number of particles based on a 30-standard-cubic-foot sample.

3 Maximum number of particles based on a 100-ml sample.

workmanship. The standards of workmanship exhibited in any approved sample, subject to any qualification stated in the Government's notice of approval, shall be determined by the requirements of the contract relative to workmanship insofar as not specifically covered by applicable specifications.

3.3.5 Interchangeability. Interchangeability and replaceability of components obtained by use of common parts shall be implemented wherever possible in accordance with paragraph 3.3.1.9 of system specification SS613M0001. Commonality in hardware and software items between the booster and orbiter vehicles will be utilized in the areas shown in Table IV.

3.3.6 Safety. Unless otherwise specified herein, the design features shall conform to the requirements of paragraphs 3.3.4.1, 3.3.4.2, 3.3.4.3, 3.3.4.4, 3.3.4.5, 3.3.4.6, and 3.3.4.9 of specification SS613M0001. The criteria for safety shall conform to the requirements of paragraph 3.2.3(c) of specification SS613M0001.

3.3.7 Human performance/human engineering. Unless otherwise specified herein, human performance/human engineering design shall conform to the requirements of paragraphs 3.3.5.1 through 3.3.5.6 of specification SS613M0001.

3.3.8 Design disciplines. The following criteria shall be followed in the design and construction of the booster.

3.3.8.1 Electrical. Unless otherwise specified, the design and installation of electrical equipment shall conform to the requirements of MIL-E-25499. Exceptions to the requirements of that specification and those documents referenced therein are:

a. Shuttle peculiar concepts including RPC's, data bus, DCM control and monitoring, and failure concepts.

b. Calculations of the wire sizes required by MIL-W-5088 for feeder and distribution will not be used.

c. Analysis of loads required by MIL-E-7016 will be modified.

d. Power quality required by MIL-STD-704 will be changed as specified in 3.7 regarding transients and steady state voltage and frequency limits.

e. Transformers and rectifiers required by MIL-P-26517, generators required by MIL-G-6099, and generator systems required by MIL-G-25704 will be modified to reflect peculiar control, monitoring, and self-test concepts.

f. Wire will conform to MIL-W-81381 except for that required for special purposes.

Table IV. Common Subsystems - Booster/Orbiter

Subsystems	Areas of Commonality
Environmental Control and Life Support	Emergency O_2 supply; blowers; control valves
Main Propulsion	Engines (GFE); prevalves; valves; propellant level sensors
Air-breathing Propulsion	Servicing fittings; servicing equipment, valves, engines
Attitude Control Propulsion	Engines; pressure regulators; check valves; fill and drain equipment; propellant valves; heat exchangers; gas generators; accumulators; turbopumps
Power	
Electric	AC generators, generator control units, hybrid and solid state remote power controllers, wire and connector types, voltage levels, quality of power, and grounding methods
Hydraulic	Fluids, pumps, and valves
Electromechanical and Integrated Avionics	Central processor/bus control units; data storage units; acquisition, control, and test units; remote operation and display units; electronic display units; alphanumeric message panels; inertial measuring units; radar altimeters; UHF/AM communications; communications antennas; recovery beacon; flight log recorder; precision ranging system interrogator
Flight Control	Hand controllers; air data sensors; master tuning

g. Connectors will conform to MIL-C-83723 except as required for interfacing with off-the-shelf equipment.

3.3.8.2 Electronic. Unless otherwise specified, electronic equipment shall be designed in accordance with MIL-E-8189, Class 5X. The installation of electronic systems and equipment shall be done in accordance with MIL-E-25366 except that electrical power characteristics shall be per paragraph 3.3.8.1 herein.

3.3.8.3 Hydraulic system. The hydraulic system shall be designed and installed in accordance with MIL-H-5440.

3.3.8.4 Pneumatic system. The pneumatic system shall be designed and installed in accordance with MIL-P-5518.

3.3.8.5 Flight control. The flight control system shall be designed to meet the requirements in the following paragraphs.

3.3.8.5.1 Control system. The design of the control system shall be such that the signals of the levels received from the guidance system can be transferred into proper movement of the aerodynamic control surfaces or controlling devices considering response time, parameter modifications such as correction for altitude, velocity, center of gravity shift, and any other functions necessary for proper vehicle flight control. Locking mechanisms shall be provided for any devices necessary for adjustment of the control system. Suitable means shall be provided to prevent undesired movement of control surfaces during the launching and boost periods. Means shall also be provided to limit the control functions of the vehicle, taking into account altitude, speed, or atmospheric conditions, in order that the maximum allowable stresses on the vehicle will not be exceeded under any operating conditions.

3.3.8.5.2 Stabilization Systems. The stabilizing system shall be designed to be compatible with and complimentary to the control system in accordance with the requirements of 3.3.8.13.

3.3.8.5.3 Stability. The CEI shall accomplish stable flight along its prescribed path and with respect to its coordinate axes, consistent with performance and structural requirements, throughout the applicable ranges of speeds and altitudes. Stability about any CEI axis during the atmospheric flight phase may be done by aerodynamic means or by the use of an automatic control system. The dynamic characteristics of the airframe-automatic control system combination shall produce satisfactory motion and flight control precision consistent with CEI configuration, mission requirements, and flight environment.

3.3.8.6 Environmental control. The environmental control system shall be designed in accordance with MIL-E-38453.

3.3.8.7 Displays and controls. Integral lighting of panels and indicators in the cockpit shall conform to the requirements of MIL-L-27160 and MIL-P-7788. Legend lights shall conform to the requirements of MIL-L-6503 and MIL-STD-411. Lettering for displays and nomenclature shall be in accordance with MIL-M-18012. Caution and warning systems shall conform to the requirements of MIL-S-38039, MIL-STD-411, and MIL-STD-203.

3.3.8.8 Flight personnel provisions. Flight personnel provisions shall be developed recognizing the guidelines defined in DH1-3, DH2-2, and associated design and human engineering criteria.

3.3.8.9 Landing system. Landing system shall be designed in accordance with the requirements of AFSC Design Handbook 2-1, Chapter 4.

3.3.8.10 Thermal protection system. Normal turnaround hangar operations shall be performed and verified without requiring removal of thermal protection sections.

3.3.8.11 Bonding protection. The CEI shall be compatible with the requirements of MIL-B-5087 to assure that structure and assembled components are free of such hazards as: lightning, static discharges, and electrical shocks, and to provide for the suppression of electromagnetic interference resulting from these hazards.

3.3.8.12 Maintainability. Design of the booster shall encompass the following maintainability requirements:

a. Subsystems shall be designed for a minimum of maintenance with ease of removal and replacement.

b. Vehicle preflight and inflight checkout subsystems should be on-board, consistent with short turnaround and low-cost operations.

c. The module removal and replacement time shall be minimized with on-board checkout and module accessibility.

d. Total booster turnaround time from landing to launch readiness shall not exceed two weeks calendar time. Normal work operations shall be considered as five days a week, two eight-hour shifts each day.

e. Normal maintenance and checkout operations shall be performed and verified without required removal of TPS section(s) excluding access panels.

3.3.8.13 Flying qualities. Flying qualities shall meet the requirements of Government-furnished specifications. In the absence of a Government-furnished specification, the CEI shall comply with the requirements of MIL-F-8785, Class III aircraft. The level of flying qualities shall be level 1 for fail operational/fail operational and level 2 for fail safe.

3.4 Documentation. In general, the booster development will be documented by this specification, engineering drawings, test plans and procedures, and engineering reports. The exact documentation required shall be specified by the contract.

3.4.1 Documents for design review and approval. The types of documents required for design review and approval shall be as follows:

a. Critical items list in accordance with MSFC drawing number 85M03885.

b. TBD.

3.5 Logistics

3.5.1 Maintenance. The definitions of levels of repairability used herein shall conform to the requirements of paragraphs 3.5.1 through 3.5.1.3 of specification SS613M0001.

3.5.1.1 Maintenance and repair cycles. Maintenance and repair cycles shall conform to the requirements specified in 3.2.4.2 herein.

3.5.1.2 Accessibility for maintenance. The physical characteristics associated with access for maintenance shall be as stated in 3.2.2.6 herein. The removal and replacement of components shall be accomplished without necessity for interrupting any other interface.

3.5.1.3 Replacement and repair. The booster shall be repaired by removing and replacing defective line-replaceable units (LRUs). Checkout to determine defective LRUs shall be accomplished by on-board checkout and fault isolation and location equipment augmented by ground test equipment. Shop maintenance is defined as all maintenance such as calibration, cleaning, and repair of LRUs beyond the inspection, removal and replacement functions described above. Shop maintenance will be performed at either the primary operating site or at a remote facility depending on the complexity of the LRU and other related factors such as time, cost, and safety.

3.5.2 Supply. Supply support shall conform to the requirements of specification SS613M0001 paragraphs 3.5.2, 3.5.2.1, and 3.5.2.2.

3.5.3 Facilities and facility equipment. Facilities and facility support equipment both new and existing shall be required in accordance with the ground system specification 76Z0501.

3.6 Personnel and training.

3.6.1 Personnel. Personnel requirements in support of this CEI shall include the following types: operational, systems control, and maintenance crew personnel.

3.6.1.1 Operational personnel. Operational personnel will consist of flight personnel, and the personnel at the launch and recovery sites.

3.6.1.1.1 Flight personnel. The flight personnel shall consist of a crew of two for all specified missions. The CEI shall be operable by a single crew member in the event of an emergency.

3.6.1.1.2 Launch and recovery personnel. Requirements for these personnel shall be in accordance with the requirements of SS613M0001, paragraphs 3.6.1.1.2, 3.6.1.1.2.1, 3.6.1.1.2.2, 3.6.1.1.2.3, and 3.6.1.1.2.4.

3.6.1.2 System control personnel. Requirements for these personnel shall be in accordance with the requirements of SS613M0001, paragraph 3.6.1.1.4.

3.6.1.3 Maintenance personnel. Maintenance personnel requirements shall be in accordance with the requirements of SS613M0001, paragraphs 3.6.1.1.3 and 3.6.1.1.3.1, and the following. The maintenance personnel shall be identified in three categories; systems mechanics, structural mechanics and electrical/avionics technicians. The total maintenance crew will be composed of personnel in these categories in the proportions of 13:5:2 respectively.

3.6.2 Training. Training shall be in accordance with the requirements of specification SS613M0001, paragraph 3.6.2 with the exceptions and additions as specified herein.

3.6.2.1 Maintenance crew training. Training shall be provided for the following specialty subgroupings:

System Mechanics	Structural Mechanics	Electrical/Avionics Technicians
Aircraft	Metal Work	Electricians
Hydraulics	Welder	Electronic
Pneumatics	Structural Assembler	Instrument
Jet Engines	Airframe	Avionics
Rocket Engines		

3.7 Major component characteristics. For purposes of this specification, the booster operating subsystems listed in 3.1.3 are classified as major components. The subparagraphs of 3.7 do not cover the following characteristics, since the general requirements for these items are specified elsewhere inthe specification and are thus generally applicable to the major components:

	Characteristics	Ref. Para.
a.	Reliability	3.2.3
b.	Maintainability	3.2.4
c.	General environmental conditions	3.2.5
d.	Transportability	3.2.6
e.	Design and construction	3.3
f.	Documentation	3.4
g.	Logistics	3.5
h.	Personnel and training	3.6
i.	Precedence	3.8

3.7.1 Body structure. The body structure shall be capable of withstanding the imposed flight loads being mated with the orbiter, supporting the orbiter during launch, ascent and being separated from the orbiter, as well as performing the other functions indicated in Figure 3.7.1-1.

3.7.1.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment described outside of this CEI, see the interface documents described in paragraph 3.1.2 herein.

Subsystem	Performance paragraph of this specification
Aerodynamic surfaces	3.7.2.2
Thermal protection	3.7.3.2
Landing system	3.7.4.2
Main propulsion	3.7.5.2
Attitude control propulsion	3.7.6.2
Airbreathing Propulsion	3.7.7.2
Guidance, navigation and control	3.7.8.2
Data and control management	3.7.9.2
Displays and controls	3.7.10.2
Communications	3.7.11.2

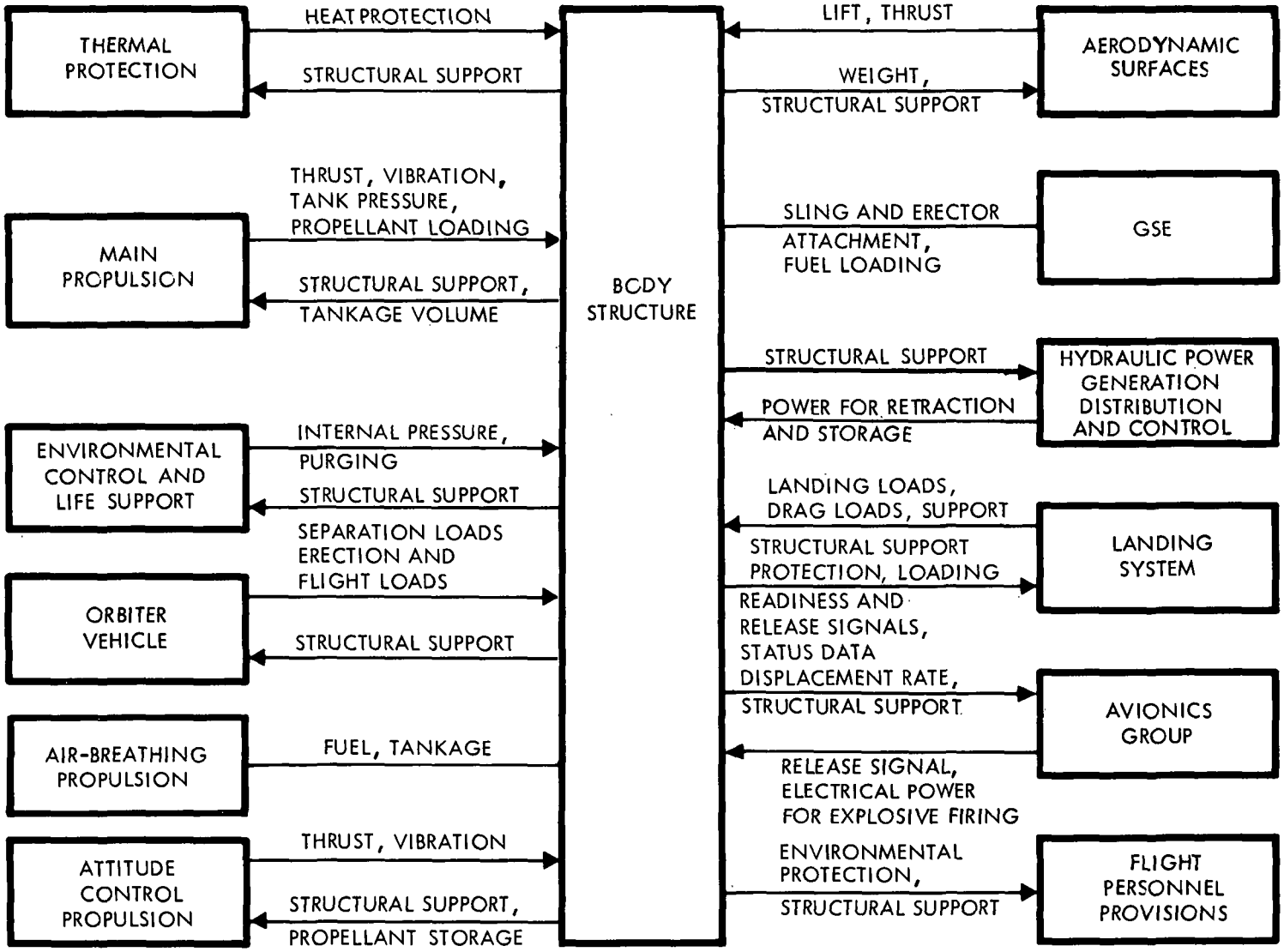


Figure 3.7.1-1. Block diagram of interfaces with body structure subsystem

Subsystem	Performance paragraph of this specification
Hydraulic power generation, distribution and control	3.7.13.2
Electric power generation, distribution and control	3.7.14.2
Environmental control and life support	3.7.15.2
Flight personnel provisions	3.7.16.2

3.7.1.2 Performance

3.7.1.2.1 Conditions for performance. The performance of the body structure shall be based upon the following conditions:

a. Factors of safety	As specified in 3.2.2.4
b. Orbiter properties	As specified in para. 3.2.1.1 herein

3.7.1.2.2 Control equations. The control equations associated with the structural loading are those specified in 76-549-30-008.

3.7.1.2.3 Loading-unloading shocks. The body structure in proximity of the propellants shall be capable of withstanding the loading and unloading dynamic pressure and thermal shock resulting from the loading rates specified in paragraph 3.2.1.6 herein.

3.7.1.2.4 Structural limit loads. The body structure shall be capable of withstanding the combined loads, including fluid shocking, induced by critical flight conditions within the limits specified herein for the life specified in paragraph 3.2.1.5 herein.

3.7.1.2.5 Maximum bending load. The body structure shall be capable of withstanding the maximum bending loads specified in 76-549-30-008.

3.7.1.2.6 Longitudinal oscillation loads. The body structure shall be capable of withstanding the maximum longitudinal oscillating loads, following engine thrust buildup and engine thrust cutoff, as specified in 76-549-30-008.

3.7.1.2.7 Maximum axial loads. The body structure shall be capable of withstanding the maximum axial loads specified in 76-549-30-008.

3.7.1.2.8 Orbiter mating and separation. The following conditions for orbiter mating and separation shall be required for the performance:

a. The separation sequencing will be under computer control (speed of response and adaptability), and will automatically start separation in the event of shut-down of all booster engines.

b. Booster and orbiter engine thrust decay and buildup shall be in accordance with predicted and documented data from the engine contractors.

c. The longitudinal acceleration provided by the booster to the orbiter shall not be below 0.10g for orbiter engine start and operation.

3.7.1.2.8.1 Separation. The orbiter mating/separation subsystem shall be capable of the performance specified in paragraphs 3.2.1.1.2 and 3.2.1.3 herein (see 6.3.4) where initiation is controlled from either vehicle.

3.7.1.2.8.2 Mating. The orbiter mating/separation subsystem shall be capable of engagement of the orbiter within 120 minutes after the orbiter is correctly positioned as described in ICD SR 2.4.4-11186.

3.7.1.3 Physical characteristics

3.7.1.3.1 General description. The body structure shall be a lightweight structural arrangement with an aerodynamic shape consistent with the overall design of the vehicle which will contain propellants in sufficient quantity to meet the performance requirements specified herein. It shall support and protect the integral interfacing subsystems and personnel from adverse environment. It shall have a general arrangement size, weight, and volume as shown in Figure 3.2.2.2-1.

3.7.1.3.2 Retraction provisions. The mating/separation subsystem shall provide for retraction and position locking of the mating/separation links and mechanism.

3.7.2 Aerodynamic surfaces. The aerodynamic surfaces shall provide lift and aerodynamics control to the booster during atmospheric flight. The other functions provided shall be those described in Figure 3.7.2-1.

3.7.2 1 Interfaces. This subsystem shall interface with the ground equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment described outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this section
Body structure	3.7.1.2
Thermal protection	3.7.3.2
Attitude control propulsion	3.7.6.2
Air-breathing propulsion	3.7.7.2
Guidance, navigation, and control	3.7.8.2
Data control management	3.7.9.2
Communication	3.7.11.2
Auxiliary power unit	3.7.12.2
Hydraulic/electric power generation, distribution, and control	3.7.13.2

3.7.2.2 Performance

3.7.2.2.1 Conditions for performance. The performance of the aerodynamic surfaces shall be based upon the following conditions:

a.	Factors of safety	As specified in TBD
b.	Orbiter properties	As specified in 3.2.1.1.
c.	Induced environment	As specified in 3.2.5.2.1.
d.	Thermal pulse from orbiter engines	As specified in 3.2.1.1.

3.7.2.2.2 Control equations. The control equations associated with the structural loading of the aerodynamic surfaces are those specified in 76-549-30-008.

3.7.2.2.3 Structural limit loads. The aerodynamic surfaces structure shall be capable of withstanding the combined loads induced by critical flight conditions as specified in 76-549-30-008, for the life specified in 3.2.1.5 herein.

3.7.2.2.4 Separation loads. The empennage shall be capable of withstanding acoustic loads and thermal shock from the orbiter engine exhaust as specified in para. 3.2.5 herein as well as the flight loads.

3.7.2.3 Physical characteristics. The aerodynamic surfaces shall have the general arrangement, size, wieght and volume as specified in paragraph 3.2.2 herein.

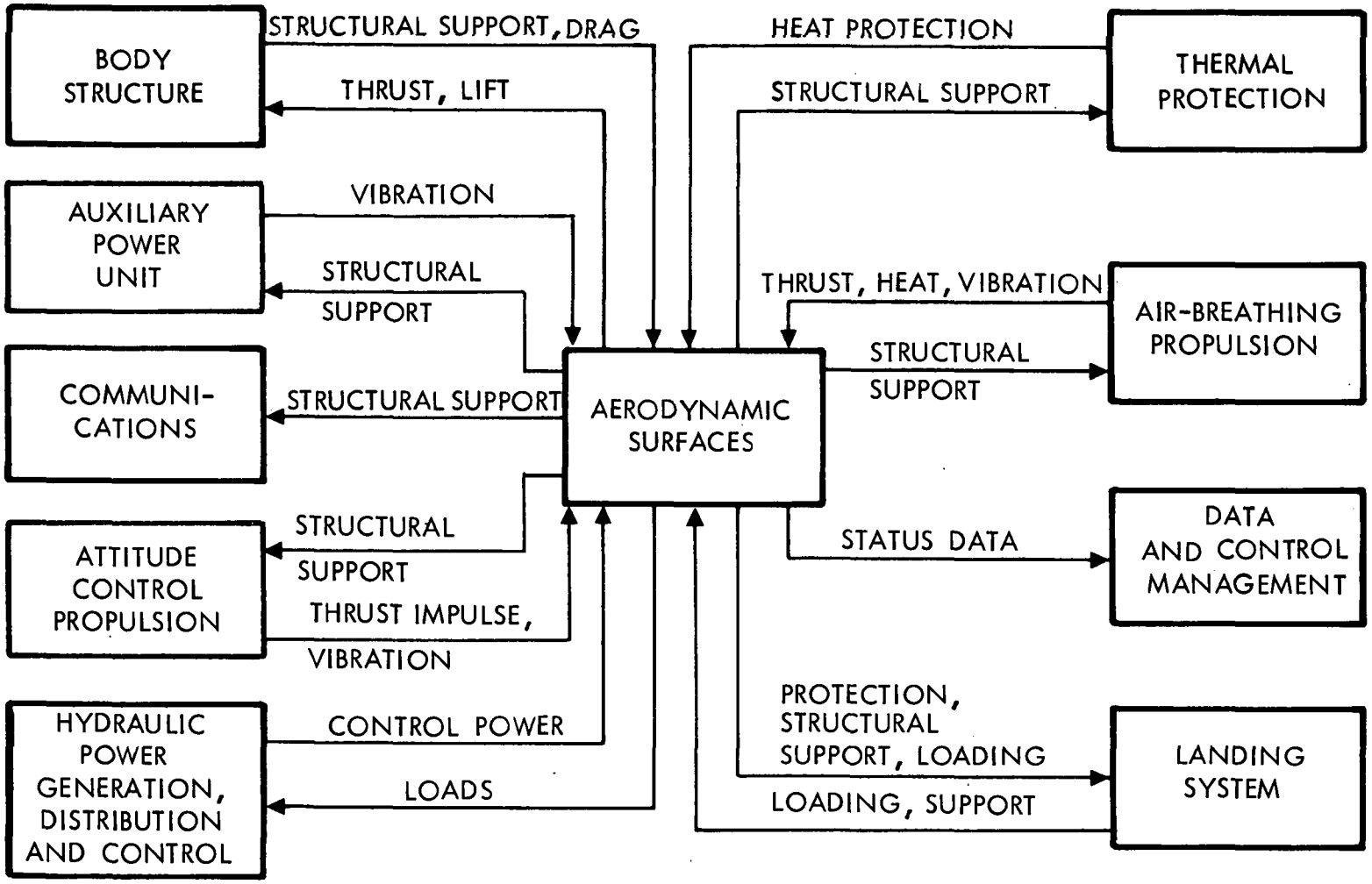


Figure 3.7.2.-1. Block diagram of interfaces with aerodynamic surfaces subsystem

3.7.3 Thermal protection. The thermal protection system shall be capable of providing protection to structure and personnel from degrading temperature effects during the boost and entry phase as well as providing the other functions indicated in Figure 3.7.3-1.

3.7.3.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems described in paragraphs referenced below. For detail descriptions of the interfaces with the equipment described outside of this CEI, see the interface documents described in paragraph 3.1.2 herein.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.1
Aerodynamic surfaces	3.7.2.2
Landing system	3.7.4.2
Main propulsion	3.7.5.2
Attitude control propulsion	3.7.6.2
Air-breathing propulsion	3.7.7.2
Data and control management	3.7.9.2

3.7.3.2 Performance

3.7.3.2.1 Conditions for performance. TBD

3.7.3.2.2 Control equations. TBD

3.7.3.2.3 Reuse. The thermal protection system shall be capable of withstanding the environment specified in 3.2.5.2 TBD times.

3.7.3.3 Physical characteristics. The thermal protection system shall have the general arrangement, size, weight, and volume as specified in 3.2.2 herein.

3.7.4 Landing system. The landing system shall be capable of providing support to the structure and other functions as indicated in Figure 3.7.4-1.

3.7.4.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with that equipment described outside of the CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Data and control management	3.7.1.2
Hydraulic/electrical power generation, distribution and control	3.7.13

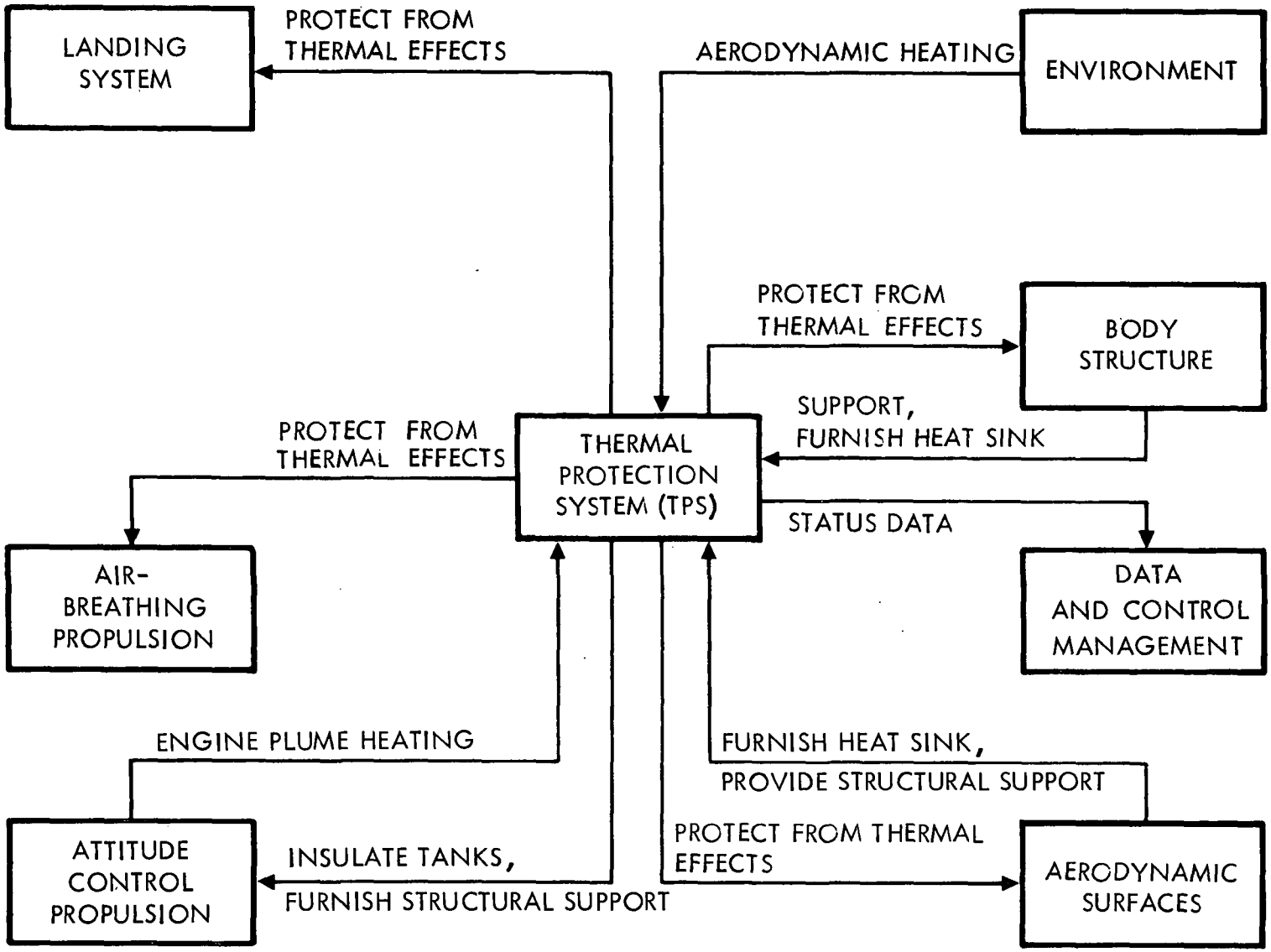


Figure 3.7.3-1. Block diagram of interfaces with thermal protection subsystem

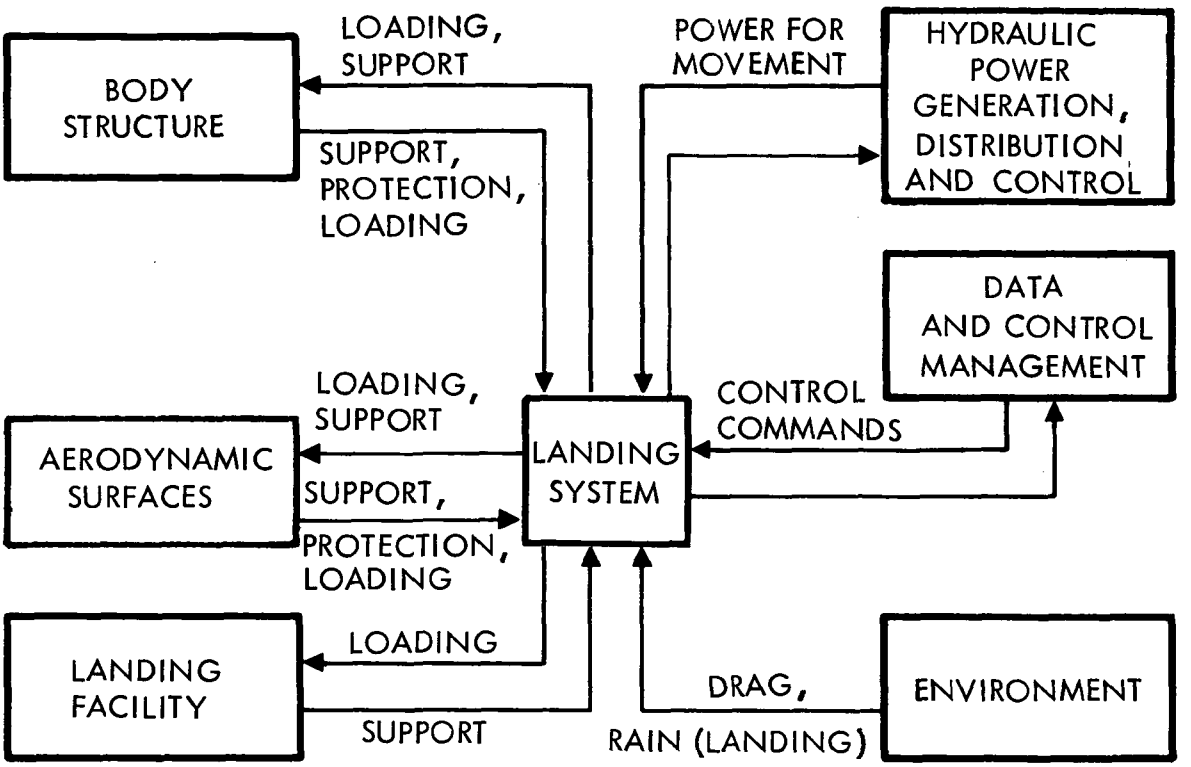


Figure 3.7.4-1. Block diagram of interfaces with landing subsystem

3.7.4.2 Performance characteristics

3.7.4.2.1 Conditions for performance. Unless otherwise specified, the performance of the landing system is based upon a standard day at sea level as defined in 3.2.1.1.7.1 with the CEI descending over a 50-foot obstacle onto a dry pavement.

3.7.4.2.2 Loading. The landing system shall be capable of withstanding the landing and takeoff load of the CEI as specified herewith with a factor of safety of TBD.

Mode of Operation	Weight	Speed	Attitude Conditions
Towing	See Table II	TBD	Horizontal
Landing (Mission)	See para 3.2.2.3		
Landing (Ferry)	See para 3.2.2.3	Para 3.2.1.2	TBD
Takeoff (Ferry)	See para 3.2.2.3	Para 3.2.1.2.1	TBD

3.7.4.2.3 Rate for extension and lockdown. The landing system shall be capable of being extended and locked down within the following times and conditions.

a. Normal system 15.0 ± 1.5 sec

b. Emergency free fall 30 sec max

3.7.4.2.4 Rate of retraction and locking. The landing system shall be capable of being retracted and locked up within the following times and conditions: normal system 15 ± 1.5 sec.

3.7.4.2.5 Braking. The landing system shall be capable of stopping the CEI within 3168 feet under the conditions specified in 3.2.1.1.7.1 using wheel brakes without a drag chute at maximum safe cross-wind conditions with a touchdown speed of 172 knots. It shall be capable of safely stopping the CEI under wet runway conditions.

3.7.4.3 Physical characteristics. The landing system shall be a conventional aircraft landing system and shall have the general size weight, and volume as described in paragraph 3.2.2.

3.7.5 Main propulsion. The main propulsion system shall be capable of providing controlled, vectoring thrust to the structure and performing other functions indicated in Figure 3.7.5-1. It shall provide thrust for the ascent phase through separation until propellants are depleted. In the event of early separation, it shall provide thrust until propellant depletion.

3.7.5.1 Interfaces. This subsystem shall interface with the support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment described outside of this CEI, see the interface documents described in paragraph 3.1.2.

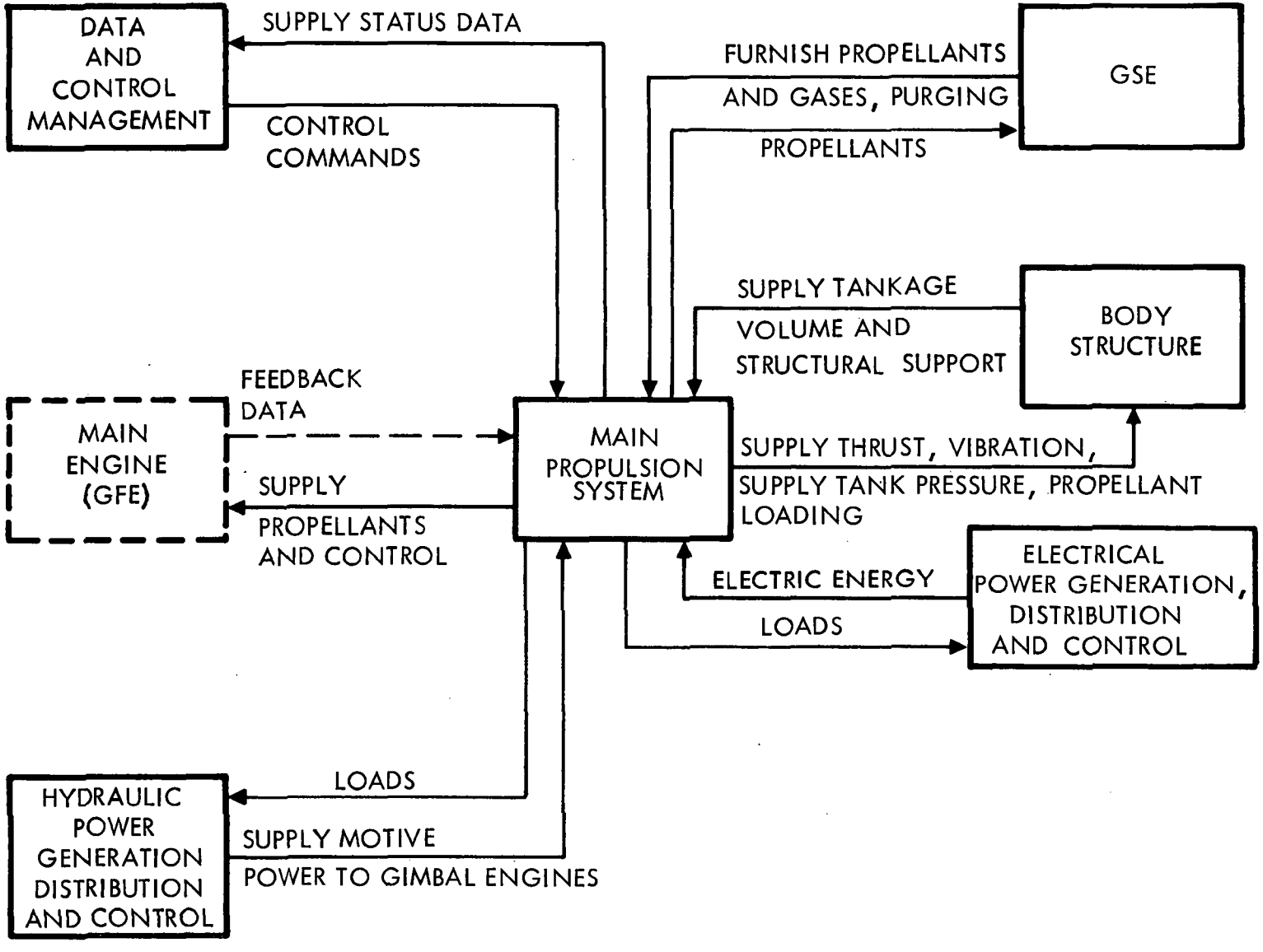


Figure 3.7.5-1. Block diagram of interfaces with main propulsion subsystem

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Thermal protection	3.7.3.2
Guidance, navigation and control	3.7.8.2
Data and control management	3.7.9.2
Hydraulic power generation, distribution, and control	3.7.13.2
Electric power generation, distribution, and control	3.7.14.2

3.7.5.2 Performance

3.7.5.2.1 Conditions for performance. The main propulsion performance shall be based upon use of GFE engines described in the specification for the engine. major characteristics are given below for reference.

Rated Thrust	550,000 lb @ sea level
Throttling Range	50 to 109% rated thrust
Operating Life	7.5 hr
Minimum Specific Impulse (At Rated Thrust)	397 sec
Nozzle Area Ratio	35:1 A_e/A_t
Mixture Ratio, Nominal	6:1 O/F
Burn duration	
@ rated thrust	500 sec
@ maximum thrust	460 sec
Mixture Ratio Control	5.5 to 6.5 O/F
Rate of Thrust Change	Less than 7×10^5 lb/sec
Gimbal Angle, Pitch and Yaw	±10.0 deg
Gimbal Rate	10 deg/sec
Gimbal Acceleration	30 rad/sec^2
Gimbal Failure, Engine Position	Null

Fluids:

a. Oxidizer — Liquid oxygen (O_2) conforming to MIL-P-25508.

b. Fuel — Liquid hydrogen (H_2) conforming to MIL-P-27201.

c. Pressurant and purge — Helium (He) conforming to MIL-P-27407.
Nitrogen (N) conforming to MIL-P-27401.

d. Cleanliness — see paragraph 3.3.1.1 herein.

3.7.5.2.2 Control equations. TBD

3.7.5.2.3 Flow rates. The system shall be capable of supplying the following flow rates with the indicated minimum pressures at engine pump inlets. The system shall be capable of supplying adequate flow for thrust rise profiles as shown in Figures 3.7.5.2.3-1 through 3.7.5.2.3-3.

	Total flow rate (lb/sec)	Pressure (psi) Start Minimum psia	Minimum NPSP	Temp (°R)
LO_2	14,100	40	NPL 8 MPL 2	163-173
LH_2	2,340	30	NPL 2 MPL 0.5	37-43

Note: NPL = Nominal power level, MPL = Minimum power level.

3.7.5.2.4 Propellant gaging. The system shall be capable of measuring at the accuracy expressed in percent of full scale as a function of remaining mass of propellant.

Loading propellant gaging: LO_2 0.64 LH_2 0.86

3.7.5.2.5 Tank pressurization. The system shall be capable of providing pressure to tankage at rates as follows:

	Nominal/press. (psia)	Relief press. (psia)	Max wt. rate (lb/min)	Nominal Temp(°R)
LO_2 tank	16.6	17.5	144	800
LH_2 tank	20	22	28	500

3.7.5.3 Physical characteristics. The main propulsion system shall have the general arrangement, size, weight and volume as specified in 3.2.2.

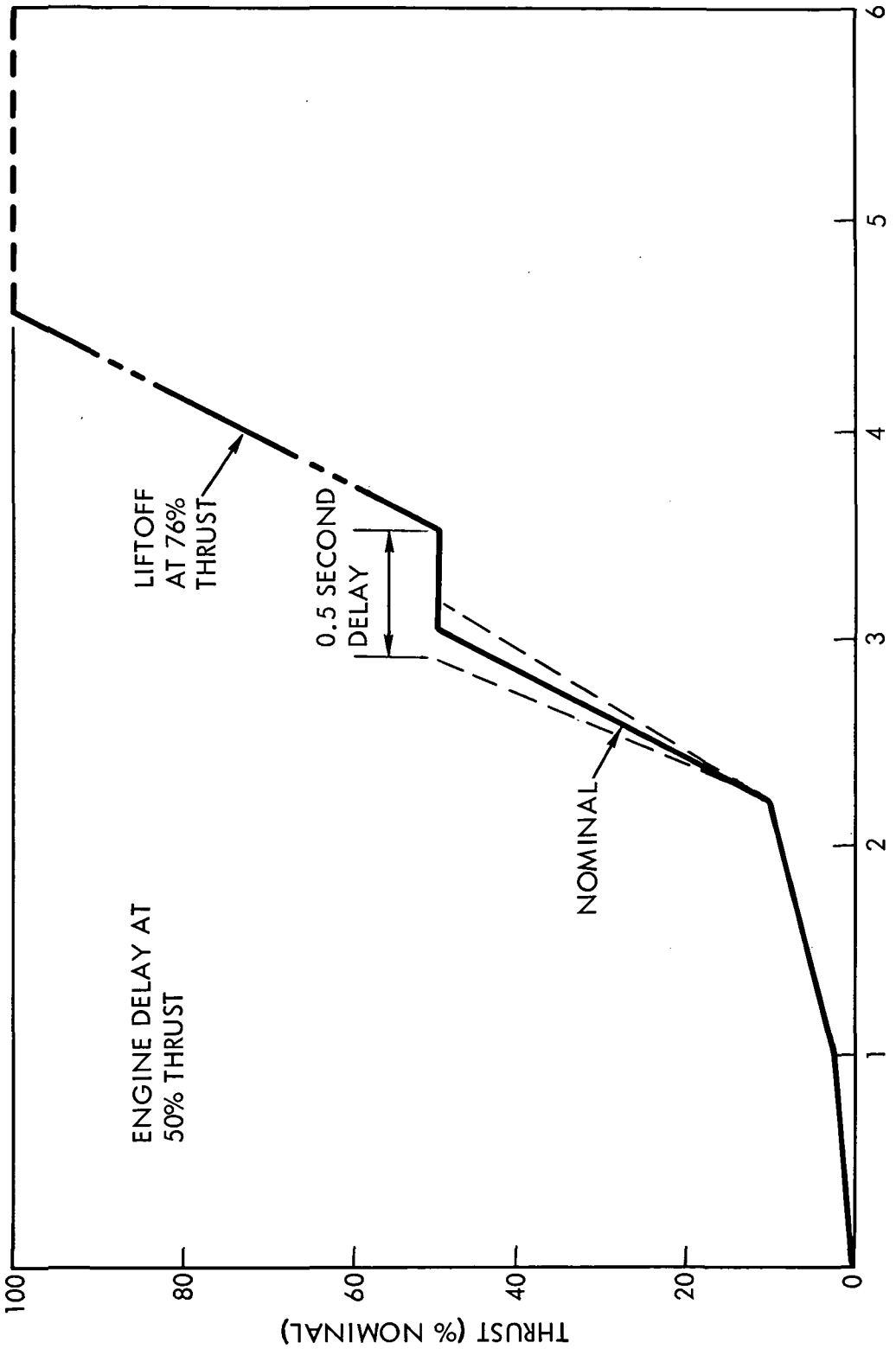


Figure 3.7.5.2.3-1. Thrust rise profile

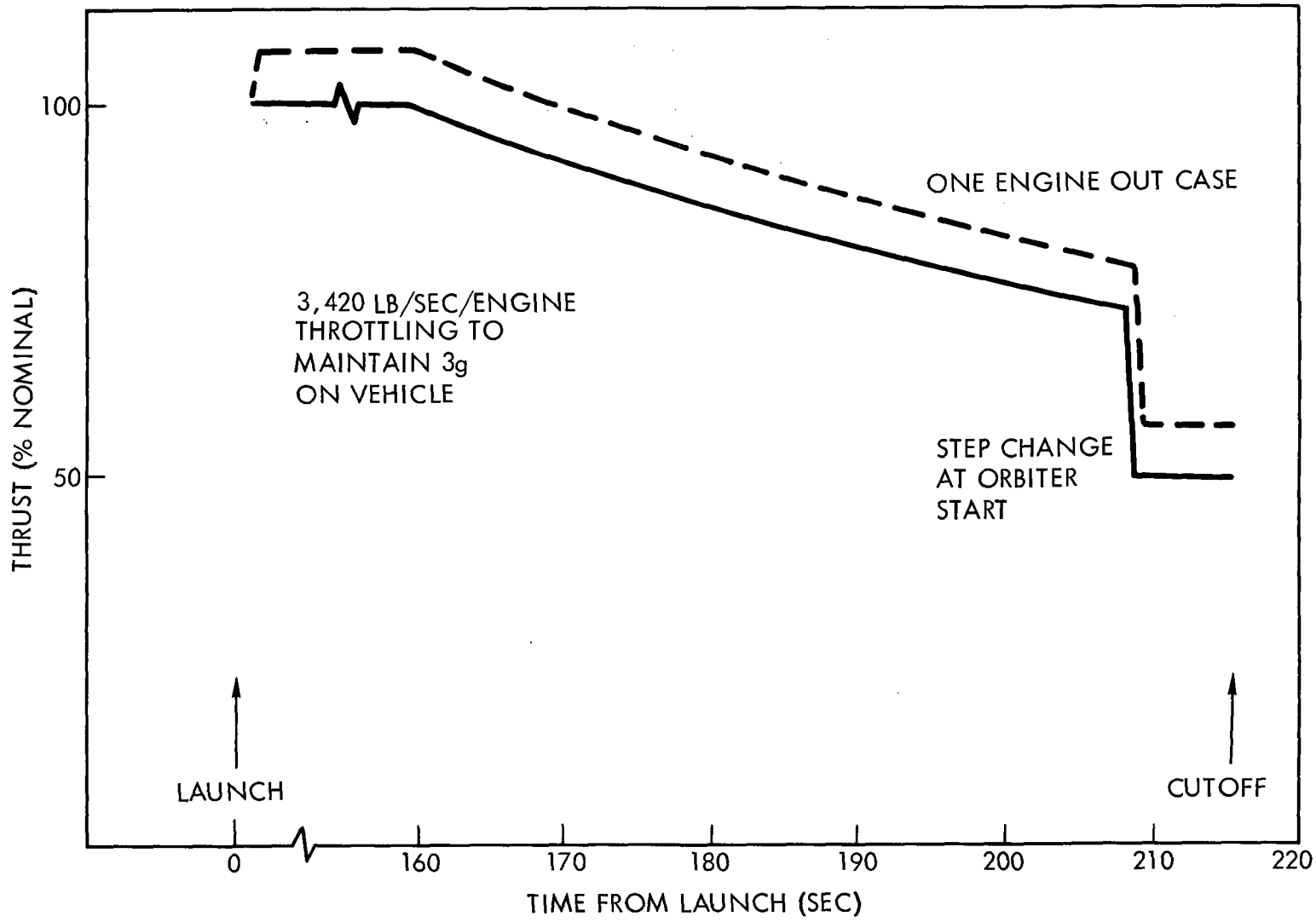


Figure 3.7.5.2.3-2. Booster throttling requirements

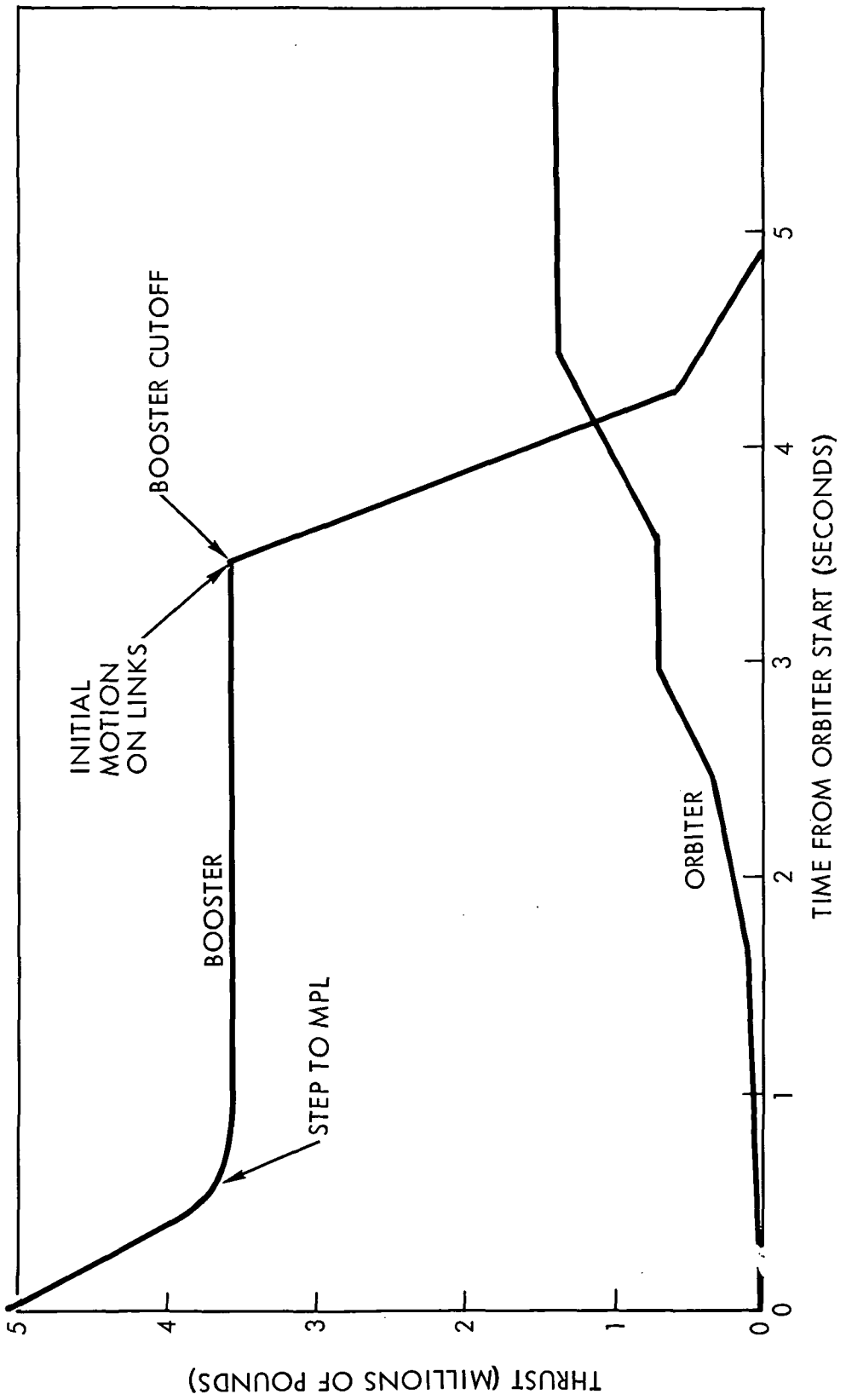


Figure 3.7.5.2.3-3. Thrust decay, normal separation

3.7.6 Attitude control propulsion. The attitude control propulsion subsystem shall be capable of providing the functions described in Figure 3.7.6-1. The subsystem shall be capable of providing three-axis rotational attitude control.

3.7.6.1 Interfaces. This subsystem shall interface with the support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment described outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Aerodynamic surfaces	3.7.2.2
Thermal protection	3.7.3.2
Data and control management	3.7.9.2
Electric power generation, distribution, and control	3.7.11.2

3.7.6.2 Performance

3.7.6.2.1 Conditions for performance. The pitch and roll thrusters shall operate until the vehicle reaches a dynamic pressure of 50 psf. The yaw thrusters shall be required to be capable of operation throughout the entry flight phase.

3.7.6.2.2 Thrust. The attitude control propulsion system shall be capable of providing thrust in both steady state and pulse mode. The minimum impulse bit per firing shall be 210 lb-sec. The thrust buildup and decay shall be as shown in Figure 3.7.6.2.2-1.

3.7.6.2.3 Propellant distribution. The attitude control propulsion system shall be capable of distribution of propellants to any engine firing sequence within the thrust level bands specified in Figure 3.7.6.2.2-1 while the CEI is in any flight attitude.

3.7.6.3 Physical characteristics. The attitude control propulsion system shall have the weight and volume described in paragraph 3.2.2.

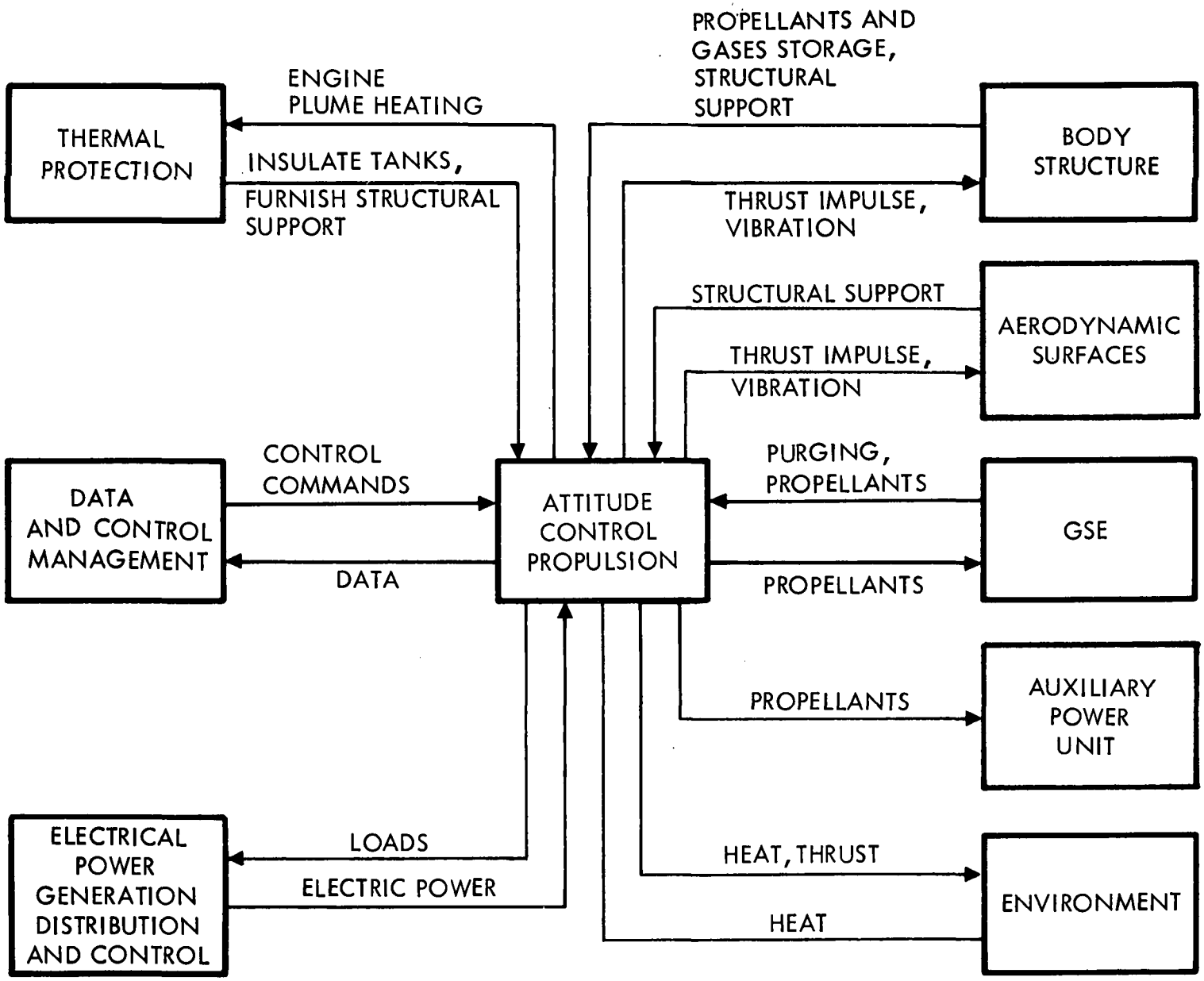


Figure 3.7.6-1. Block diagram of interfaces with attitude control propulsion subsystems

TBD

Figure 3.7.6.2.2-1. ACPS thrust build up and decay

3.7.7 Air-breathing propulsion. The air-breathing propulsion subsystem in the booster shall be designed to use JP as an engine fuel. The subsystem shall provide the thrust in atmospheric flight after entry and through landing as well as the thrust necessary for the ferry mission (see Figure 3.7.7-1).

3.7.7.1 Interfaces. This subsystem shall interface with the support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Aerodynamic surfaces	3.7.2.2
Thermal protection	3.7.3.2
Data and control management	3.7.9.2
Hydraulic power generation, distribution and control	3.7.13.2
Electric power generation, distribution and control	3.7.14.2
Environmental control and life support	3.7.15.2

3.7.7.2 Performance

3.7.7.2.1 *Conditions for performance*. TBD

3.7.7.2.2 Thrust levels. The air-breathing propulsion system shall be capable of providing total thrust at the following levels and under the following conditions:

a. Start of Cruise. The air-breathing propulsion system shall be capable of delivering 120,000 pounds of thrust at maximum continuous power setting at an altitude of 10,000 feet and a Mach number of 0.5. Ambient conditions are those specified for this altitude by TMX-53872. One engine shall be inoperative in determining total thrust for this situation.

b. Takeoff. The air-breathing engine system shall be capable of deliverying 210,000 pounds of static thrust at an intermediate power setting with all engines operating. Ambient conditions are those specified by TMX-53872 at sea level. This thrust level shall not be less than 190,000 pounds at M = 0.4 for the same ambient conditions.

3.7.7.2.3 Noise and vibration output. The air-breathing propulsion system shall generate noise within the limits specified in paragraph 3.2.5.2. The vibration from the engine measured at TBD shall not exceed the values specified in environmental specification.

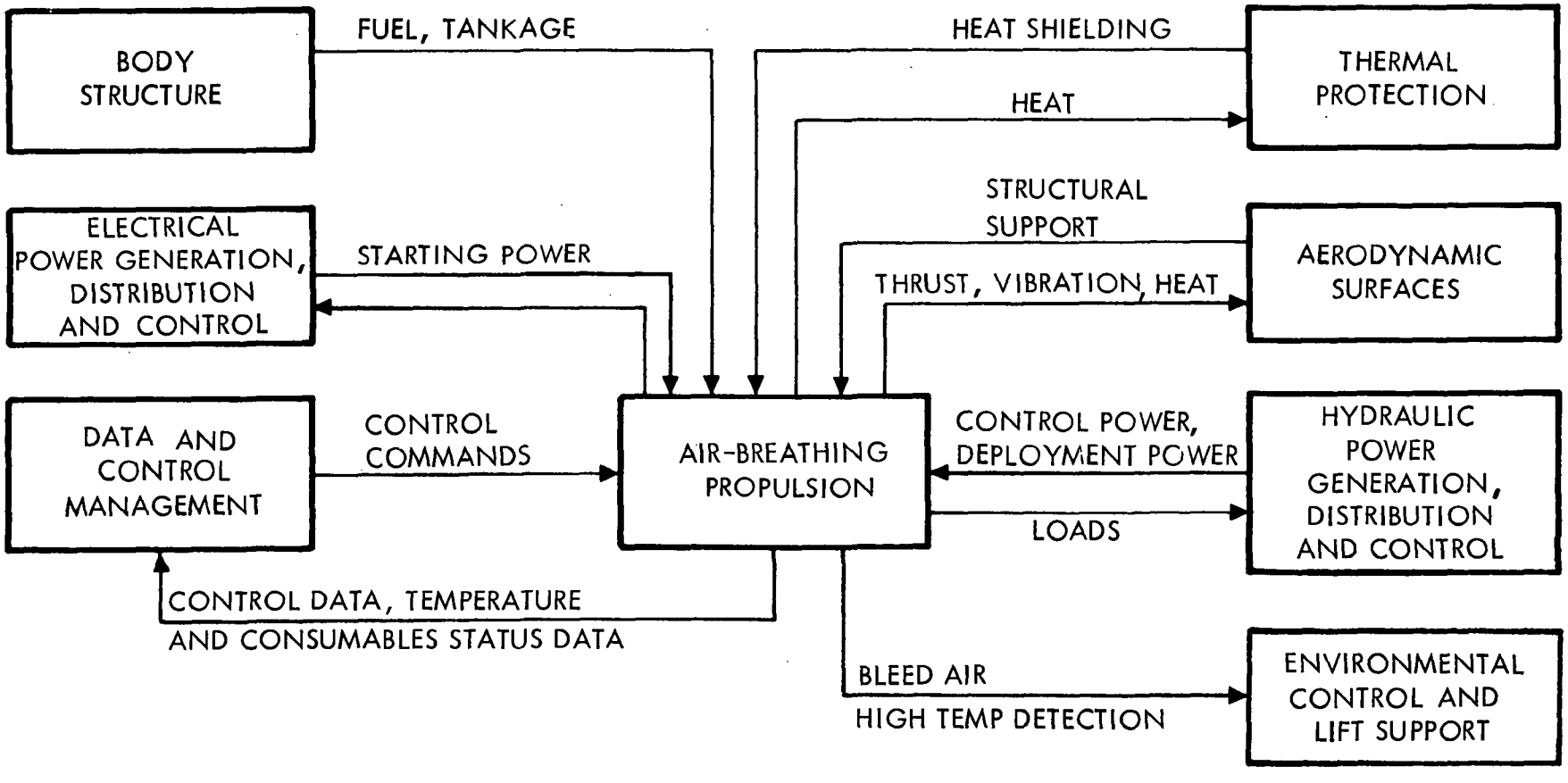


Figure 3.7.7-1. Block diagram of interfaces with air breathing propulsion subsystem

3.7.7.2.4 Temperature detection. The air-breathing propulsion system shall be capable of detection of temperatures of fires in the engine compartment or nacelles without false alarm at any operating conditions within the following limits:

High temperature T_H = TBD

3.7.7.2.5 Engine deployment time. The air-breathing engine system shall be capable of being deployed and started while airborne during the operation phase in 3.2.1.1.3 within 90 seconds.

3.7.7.2.6 Propellant loading rates. The air-breathing propulsion system shall be capable of being loaded at the following maximum rates for not more than the time specified in 3.2.1.1.6:

a. With CEI in vertical attitude, 144,000 lb in 44 minutes.

b. With CEI in horizontal attitude, 144,000 lb in 44 minutes.

3.7.7.3 Physical characteristics. The air-breathing propulsion system shall have the general arrangement, size, weight, and volume as described in paragraph 3.2.2.

3.7.8 Guidance, navigation and control. The guidance, navigation, and control (GN&C) subsystem, in conjunction with its associated displays/controls and the data and control management (DCM) subsystem, shall be capable of providing guidance, navigation, and control for the booster. The GN&C subsystem shall be capable of providing fully automatic operation with the exception of rollout and braking. The capability for manual control of the vehicle shall be provided. The GN&C subsystem shall provide a fail operational/fail safe hybrid failure concept with switch-out of the malfunctioning functional path by the DCM subsystem. The checkout and fault isolation capability of the DCM subsystem shall be utilized to permit the GN&C subsystem to be operationally checked and faults to be isolated. The GN&C subsystem shall be capable of performing the following functions, for which computations are actually done in the DCM subsystem:

a. Compute maneuver times and steering commands.

b. Provide automatic and manual three axis rotational control.

c. Provide aerodynamic load relief, as necessary.

d. Suppress body bending and fluid sloshing.

e. Guide the vehicle automatically during ascent phase for proper release of the orbiter.

f. Guide the vehicle automatically during entry, cruise, and landing phases.

g. Supply stability augmentation for manual control.

h. Navigate to within range of landing aids.

i. Hold heading, altitude, airspeed, and attitude automatically.

j. Automatically control landing.

k. Permit manual control override.

3.7.8.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems as shown in Figure 3.7.8.1-1 and described in the paragraphs referenced below. The GN&C subsystem interface with the displays and controls, communications, hydraulic, attitude control propulsion, airbreathing propulsion, and landing gear subsystems shall be via the data and control management subsystem and its associated data bus. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Data and control management	3.7.9.2

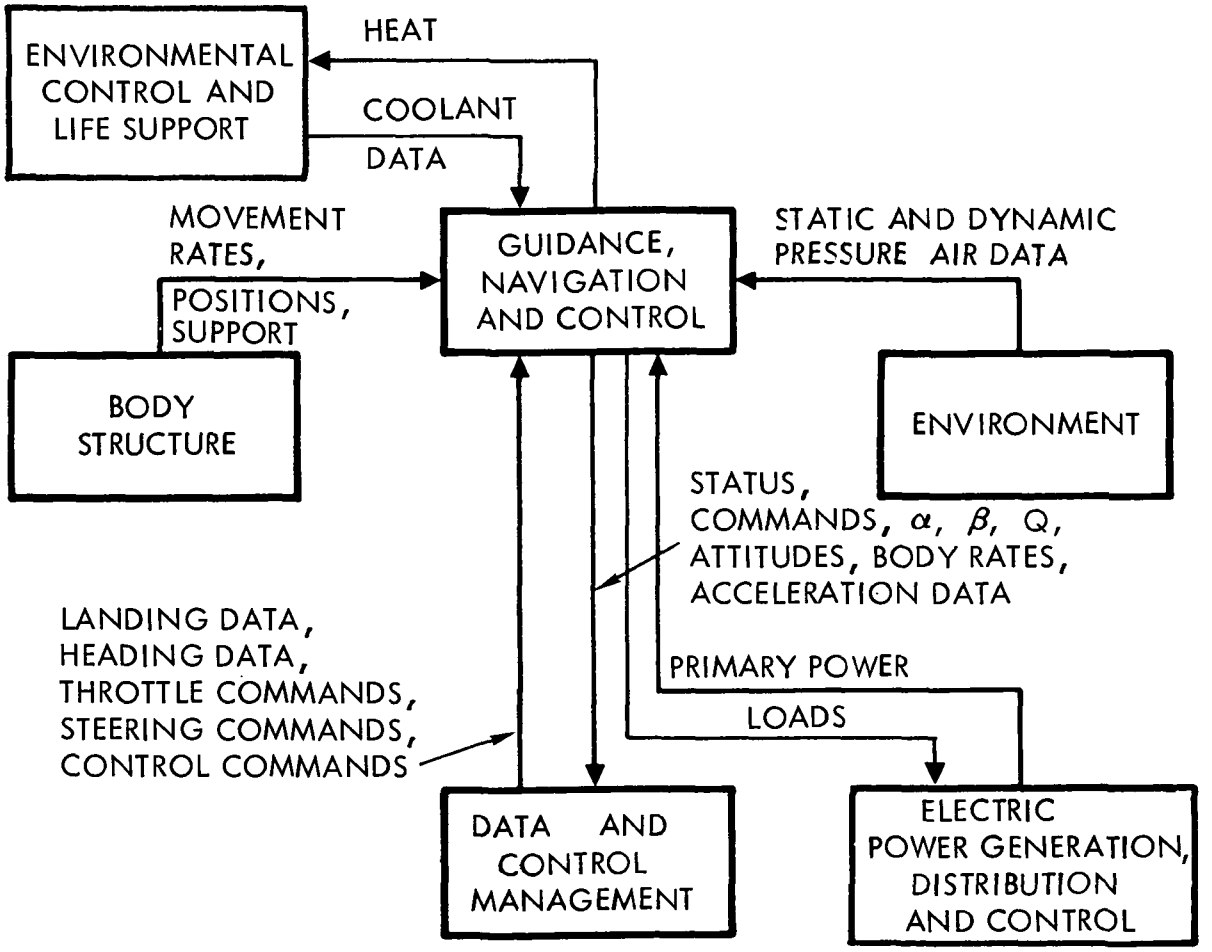


Figure 3.7.8.1-1. Block diagram of interfaces with guidance, navigation and control subsystem

Subsystem	Performance paragraph of this specification
Electric power generation, distribution, and control	3.7.14.2
Environmental control and life support	3.7.15.2

3.7.8.1.1 Checkout and fault isolation (COFI). The COFI capability of the DCM subsystem shall be utilized by the GN&C subsystem to provide the following functions:

a. Determine the GN&C subsystem's performance or readiness to perform all flight and postflight operations during prelaunch.

b. Provide the capability to simulate dynamic operating conditions (simulated stimuli) to the degree necessary to support ground trouble shooting and re-certification of line replaceable units (LRU's) during maintenance and refurbishment periods.

c. Provide the capability to detect, verify, and isolate faults to the functional path level for operational purposes and to the LRU level for maintenance purposes.

d. Provide the capability for acquisition and storage of information to be used for postflight analysis and preventive maintenance.

3.7.8.2 Performance

3.7.8.2.1 Conditions for performance. TBD

3.7.8.2.2 Control equations. TBD

3.7.8.2.3 Inertial measurement unit alignment. The GN&C subsystem shall be capable of self aligning to within 0.0015 radian in azimuth and 0.0002 radian in vertical.

3.7.8.2.4 Engine alignment. The GN&C subsystem shall provide commands to align the main propulsion engines to within the limits of their required initial position as specified in specification 13M15000.

3.7.8.2.5 Inertial measurement unit outputs (IMU). The GN&C subsystem shall provide IMU outputs in response to change of angle about each vehicle axis and change of velocity along each vehicle axis. The IMU outputs shall have the following accuracies:

Parameters	Accuracy (Allocated)	Signals
Drift in angular measurement (at 0 g)	0.02 deg/hr	TBD

Parameters	Accuracy (Allocated)	Signals
G sensitive drift in angular measurement	0.05 deg/hr/g	TBD
Non-time dependent angular measurement errors	±1 minute of arc	TBD
Accelerometer bias errors	2×10^{-4} g	TBD
Accelerometer scale factor error	0.015%	TBD

3.7.8.2.6 Body bending suppression. Rate sensors shall be provided to sense localized body rates at specified vehicle locations. The outputs from these sensors shall be used by the GN&C subsystem in suppressing body bending deflections to safe limits as specified in 3.7.1.2.5. Each sensor shall have the following characteristics about its sensitive axis:

Axis	Range (Allocated)	Accuracy (Allocated)	Signals
Pitch	100 deg/sec	0.1 deg/sec	TBD
Yaw	100 deg/sec	0.1 deg/sec	TBD
Roll	100 deg/sec	0.1 deg/sec	TBD

3.7.8.2.7 Aerodynamic load relief. The GN&C subsystem shall limit aerodynamic loading during the ascent phase to alpha-q to less than ±2800 psf-deg and beta-q to less than ±1600 psf-deg as specified in 3.2.1.1.1.1.

3.7.8.2.8 Trajectory. The GN&C subsystem shall provide automatic thrust vector control so as to satisfy the trajectory requirements of paragraph 3.2.1.1.

3.7.8.2.9. Separation state vector. The GN&C subsystem shall guide the vehicle so as to establish the initial state vector for the orbiter just prior to separation to the following accuracies for the values given in paragraph 3.2.1:

Component	Velocity (fps)	Position (ft)	Signals
Downrange	±3	200	TBD
Crossrange	±20	1000	TBD
Vertical	±5	200	TBD

Axis	Attitude (deg)	Attitude Rate (deg/sec)	Signals
Pitch	±0.1	±0.1	TBD
Yaw	±0.1	±0.1	TBD
Roll	±0.1	±0.1	TBD

3.7.8.2.10 State vector update. The GN&C subsystem shall provide periodic update of the state vector for the CEI to the following accuracies:

Phase	Horizontal Position (n.mi.)	Altitude (ft)	Velocity (ft/sec)	Signals
Ascent	TBD	TBD	TBD	TBD
Separation/Coast	TBD	TBD	TBD	TBD
Entry/Transition	TBD	TBD	TBD	TBD
Aerodynamic Flight	TBD	TBD	TBD	TBD

3.7.8.2.11 Non-atmospheric automatic attitude control. An automatic attitude hold mode shall be capable of controlling the booster attitude via the attitude control propulsion subsystem to ±1.0 degree in all axes, in order to meet the accuracy specified in paragraph 3.2.1.

3.7.8.2.12 Non-atmospheric manual attitude control. A manual attitude control mode shall be provided for control of booster rotation via the attitude control propulsion subsystem. Rotation rate control shall be provided proportional to rotational controller displacement. Maximum rotational controller displacement shall command the following rates:

Axis	Rotational Rate (deg/sec)	Signal
Pitch	2.0 ±0.1	TBD
Yaw	2.0 ±0.1	TBD
Roll	2.0 ±0.1	TBD

3.7.8.2.13 Aerodynamic automatic attitude control. An automatic mode of control shall provide the following capabilities:

Controlled Parameter	Command Range (deg)	Control Accuracy (deg)	Signals
Pitch angle	+60 -10	±1.0	TBD
Yaw angle	±5	±0.5	TBD
Roll angle	±90	±2.0	TBD

3.7.8.2.14 Atmospheric manual attitude control. Manual control shall provide sufficient artificial stability augmentation in all axes to enable the closed loop response to comply with MIL-F-8785. The booster response shall be as follows:

a. Pitch — The control parameter shall be pitch rate with maximum control stick displacement commanding 10 deg/sec.

b. Yaw — The control parameter shall be rudder displacement to assist in deliberate miscoordination of the vehicle with maximum pedal differential displacement commanding full available rudder.

c. Roll — The control parameter shall be roll rate with maximum control stick displacement commanding 40 deg/sec.

3.7.8.2.15 Hypersonic stability and control. Automatic stability and control shall be provided during the hypersonic aerodynamic flight phase for booster rate and angle ranges as follows:

Parameter	Range	Signals
Angle of attack	+60 deg to +20 deg	TBD
Bank rate	±5 deg/sec	TBD
Angle of sideslip	±5 deg	TBD

3.7.8.2.16 Subsonic stability and control. Automatic stability and control shall be provided during the subsonic aerodynamic flight phase for booster rate and angle ranges as follows:

Parameter	Range	Signals
Pitch angle of attack	+ 20 deg to 0 deg	TBD
Roll rate	± 5 deg/sec	TBD
Yaw angle of sideslip	±10 deg	TBD

3.7.8.2.17 Air data sensing. The GN&C subsystem shall provide sensors for data to derive the following parameters during the aerodynamic flight phase (see 3.2.1.1.4, 3.2.1.1.5, 3.2.1.1.6, 3.2.1.1.7.3, and 3.2.1.2):

Parameter	Range	Accuracy
Angle of attack	+65 deg to -10 deg	±2.0 deg
Angle of sideslip	±10 deg	±0.5 deg
Dynamic pressure	+800 psf	±80 psf
Indicated airspeed	(TBD) knots	(TBD) knots

3.7.8.2.18 Computed glideslope intercept. The GN&C subsystem shall be capable of guiding the booster to intercept the predetermined glideslope with the following accuracies:

Parameter	Accuracy
Range error	(TBD) n.mi.
Lateral error	(TBD) ft

Parameter	Accuracy
Altitude error	(TBD) ft
Heading error	(TBD) deg

3.7.8.2.19 Handling (aerodynamic). The GN&C system shall meet the aerodynamic handling qualities specified in 3.3.8.13.

3.7.8.2.20 Booster landing. Landing shall be possible under FAA Category II conditions. The communications subsystem shall supply the multilateration and radar altimeter data.

3.7.8.2.20.1 Computed glideslope tracking. The GN&C subsystem shall be capable of tracking the predetermined glideslope and controlling the booster within the following limits (see 3.2.1.1.5, 3.2.1.1.6, and 3.2.1.1.7):

Parameter	Limit
Altitude	(TBD) ± (TBD) ft
Lateral position	(TBD) ± (TBD) ft
Airspeed	(TBD) ± (TBD) knots

3.7.8.2.20.2 Flare. Flare shall automatically be controlled to achieve the following booster conditions at touchdown (see 3.2.1.1.7.1):

Parameter	Limit
Sink rate	(TBD) ± (TBD) ft/sec
Roll angle less than	(TBD) deg
Yaw angle less than	(TBD) deg

3.7.8.2.20.3 Rollout, braking, and steering. Following touchdown, the booster rollout path shall be manually controlled. (TBD) pounds of force on the brake pedals shall command maximum braking. An antiskid function shall prevent wheel lockup. Fore-aft motion of the rudder pedals following touchdown shall provide nosewheel steering.

3.7.8.2.21 Ferry flight. The GN&C subsystem shall be capable of manual control of the booster during horizontal takeoff, climb to cruise altitude, and automatic flight control and landing under FAA Category II conditions.

3.7.8.3 Physical characteristics. The GN&C subsystem shall have the general size, weight, and volume as described in 3.2.3 herein.

3.7.9 Data and control management. The data and control management (DCM) subsystem shall be capable of computing data for data acquisition, processing, analysis, and distribution of information to the crew and other using vehicle subsystems. Instrumentation capability shall be provided for acquiring subsystem status, performance, maintenance, and trend data by means of sensors during checkout and operational modes; conditioning the data; recording selected data for analysis purposes, and providing timing signal generation and distribution. The DCM subsystem shall perform on-board computerized functions for guidance, navigation, flight control, vehicle subsystems data management, vehicle subsystems configuration and sequencing control, integrated displays and controls, checkout and fault isolation (COFI) capability, mission history recording, and data bus control. The DCM subsystem shall consist of central processor units (CPU's), main storage units (MSU's), input/output units (I/O's), mass memory units (MMU's), and a redundant digital data bus. The DCM computer, consisting of the CPU's, MSU's, and I/O's, shall provide the primary processing and/or computing functions essential to the operation and checkout of the vehicle subsystems. The MMU's shall provide additional storage capacity. The digital data bus shall provide the major means of transferring data between the DCM computer and the vehicle subsystems. The DCM subsystem shall be capable of the following acquisition, computation, and command functions:

a. Data acquisition — Acquire data by processing status information from vehicle subsystems into a standardized interface unit.

b. Data processing — Process the acquired status information and command vehicle subsystems operations for normal or abnormal modes.

c. Display data processing — Process acquired vehicle subsystems data and transmit the processed data to the displays and controls subsystem.

d. Mission data processing — Provide mission planning inputs and compute mission variables.

e. On-board data storage — Select and store vehicle subsystems data and flight status information for postflight evaluation.

f. Guidance, navigation, and control (GN&C) computation — Solve GN&C problems and transmit the maneuver information to the vehicle subsystems.

g. Configuration and sequencing control — Monitor vehicle subsystems inputs and program vehicle subsystems operation and sequencing.

h. Control and test signal generation — Generate, process, and transmit test and control signals to booster subsystems.

i. Booster/orbiter data link — Receive, store, and process data to and from the orbiter via the communications subsystem.

j. On-board checkout and fault isolation — Accept and process status data from the vehicle subsystems, determine the subsystem operational status, isolate subsystem failures, signal the activation of the redundant units, and transmit test and status information to the displays and controls subsystem.

3.7.9.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems as shown in Figure 3.7.9.1-1 and described in the paragraphs referenced below. The DCM subsystem interface with all the vehicle subsystems shall be via the DCM data bus. For detail descriptions of the interfaces with the equipment described outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Aerodynamic surfaces	3.7.2.2
Thermal protection	3.7.3.2
Landing system	3.7.4.2
Main propulsion	3.7.5.2
Attitude control propulsion	3.7.6.2
Air-breathing propulsion	3.7.7.2
Guidance, navigation, and control	3.7.8.2
Displays and controls	3.7.10.2
Communications	3.7.11.2
Auxiliary power unit	3.7.12.2
Hydraulic power generation, distribution, and control	3.7.13.2
Electric power generation, distribution, and control	3.7.14.2
Environmental control and life support	3.7.15.2

3.7.9.1.1 Standard interface with all subsystems. The DCM subsystem shall provide the interface characteristics shown below for analog signals from other subsystems:

Amplitude	0 - 5 volts
Input impedance	1 meg ohm shunted by 50 pf
"Off" back current	≤ 0.1 microamp
Over-voltage	No permanent damage by ±35 volts

a. The DCM subsystem shall provide the following interface characteristics for discrete signals from the other subsystems:

Amplitude	TBD volts ON
	TBD volts OFF

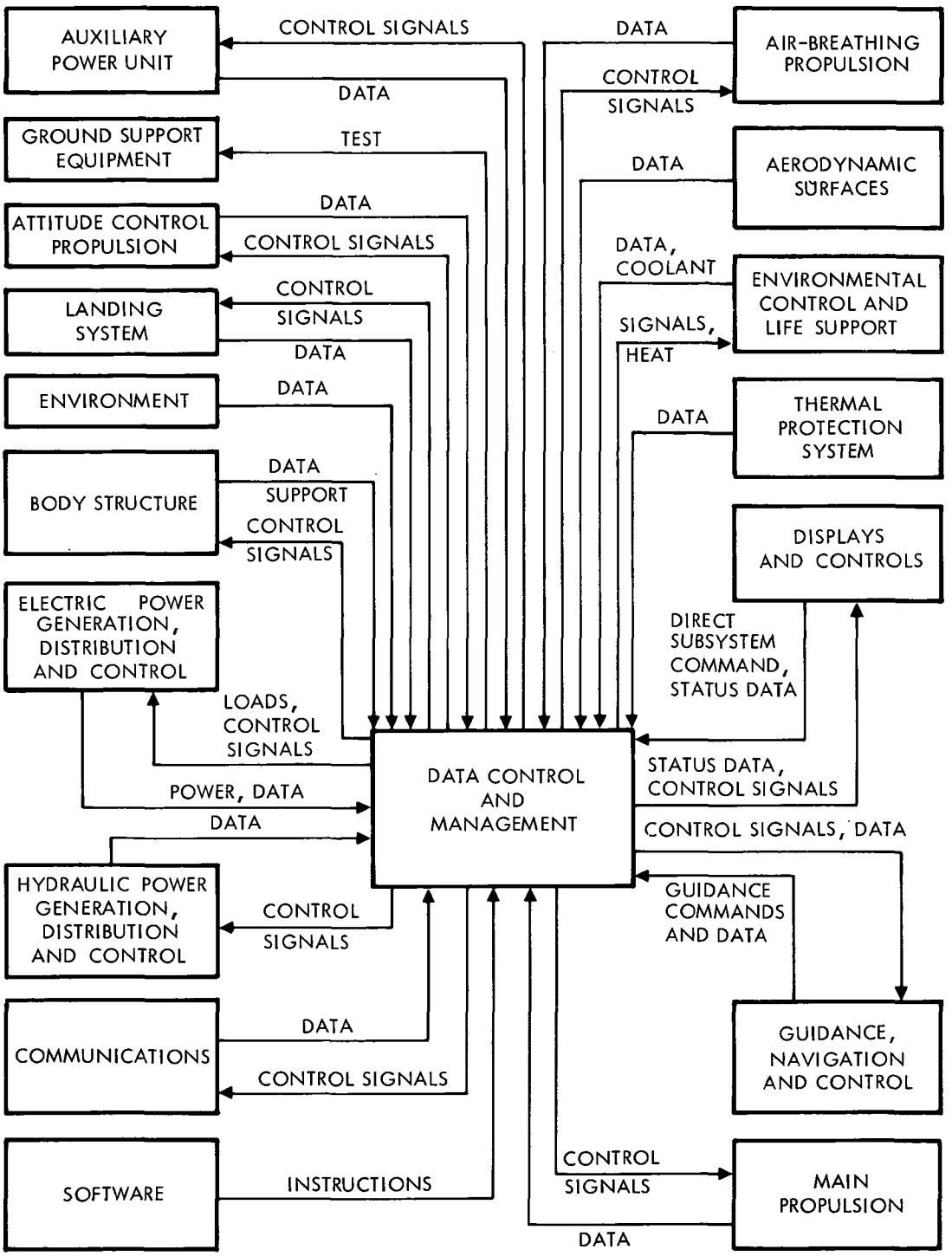


Figure 3.7.9.1-1. Block diagram of interfaces with data and control management subsystem

Input impedance	TBD ohms
Source impedance	TBD ohms ON
	TBD ohms OFF

b. The DCM subsystem shall provide the following interface characteristics for serial digital signals from the other subsystems:

Type of line	TBD (Differential or single wire)
Signal type	NRZ
Logic level	Nominal 5 volts for "1"
	Nominal 0 volts for "0"
Source impedance	TBD ohms "1"
	TBD ohms "0"
Bit rate	1 megabit/sec
Block length	8 bits
Signal exchange control	TBD

c. Outputs from the DCM subsystem shall have the following characteristics:

Analog signals

Output voltage	0 - 5 volts
Output voltage accuracy	TBD
Output impedance	TBD ohms
Maximum permissible load	TBD ohms minimum

Discrete signals

Output voltage	Nominal 0 volts OFF
	Nominal 5 volts ON
Load impedance	500 ohms
Output impedance	TBD ohms ON
	TBD ohms OFF

Serial digital signals

Type of line	TBD (Differential or single wire)
Signal type	NRZ
Logic level	Nominal 5 volts for "1"
	Nominal 0 volts for "0"
Source impedance	TBD ohms "1"
	TBD ohms "0"
Bit rate	1 megabit/sec
Block length	8 bits
Signal exchange control	TBD

3.7.9.1.2 Special interfaces. At the interface with the flight log recorder, orbiter/booster data link, and the remote operation and display units, the DCM subsystem shall provide all of the characteristics described in 3.7.9.1.1 plus the following:

Capability of separating and buffering data from other interface units	Number of other units TBD
Output data rate	TBD
Capability of accepting external clock for output of data	Details of interface TBD

3.7.9.2 Performance

3.7.9.2.1 Conditions for performance. TBD

3.7.9.2.2 Central processor unit. The CPU shall be capable of addressing all of the main storage and mass memory units; performing arithmetic and logical processing of data and sequencing instructions; processing interrupts; and commanding input/output operations. The CPU shall be capable of operating on 16 and 32 bit plus parity data and instruction words.

3.7.9.2.2.1 Computing rates. The computational speed of the CPU shall be at least 400,000 additions per second, main memory to register. Multiply and divide instructions shall be executed at a computation rate of at least (TBD) computations per second, main memory to register. The instruction set shall include the following:

(TBD)

3.7.9.2.2.2 Program load. An initial program loader shall be included, hardwired, to allow boot strap loading of the MSU's from the MMU's. A system reset function shall be included which will cause the CPU to begin executing instructions at a predefined storage location.

3.7.9.2.2.3 Addressing. The CPU shall be capable of directly addressing at least 32,000 full words of main memory. Extended addressing shall be included to address at least twelve 8 k modules of main memory. Immediate addressing, indirect addressing, and indexing capability shall be provided.

3.7.9.2.2.4 Clock. At least two hardware countdown clocks shall be provided. Each clock shall be individually loaded by the program and shall decrement itself at a maximum of once every 60 microseconds and have a maximum countdown time of at least 3 seconds. As each clock is decremented to zero, it shall cause a separate interrupt. The clock shall be accurate to at least (TBD). An interval interrupt shall be derived from the clock at a rate of approximately 25 interrupts per second. The interrupt period shall be accurate to (TBD).

3.7.9.2.3 Main storage unit. The MSU shall be a random access, electrically alterable memory with the capability of reading or storing full words and half words.

A full word is 32 data or instruction bits plus parity and memory protect bits; a half word is 16 data or instruction bits plus parity and memory protect bits. The MSU shall have sufficient capacity to provide the following:

a. Capacity to hold a simplex program (and data) of 40,960 full words.

b. Redundant storage, as required, to implement the fault detection and recovery requirements.

c. Spare storage to enable the MSU to be fully operational after two faults and support a safe return after three faults.

3.7.9.2.3.1 Addressing. Any of the MSU storage locations shall be capable of access by any CPU or input/output unit. Multiple and/or simultaneous requests shall be resolved by priority logic. Service shall normally be on a first-come-first-served basis. If more than one request is made upon the main memory, the unanswered request shall be preserved until serviced. If the hardware is partitioned so that common memory is used to back up the operating memory, to provide FO/FO/FS fault tolerance, such common memory shall be accessible by all CPU's and priority logic shall be provided to handle simultaneous or overlapping requests.

3.7.9.2.4 Input/output unit. The I/O portion of the DCM computer shall communicate with the rest of the vehicle subsystems via the data bus. This bus interface shall be serial at a 1 MHz bit rate. The I/O shall also have a serial channel to the mass memory. The serial channels to the data bus and mass memory shall be buffered and controlled to permit simultaneous operation of both serial channels while allowing the CPU to continue processing. An interface with the master timing unit shall also be provided

3.7.9.2.4.1 Parity and checks. The I/O transfers shall have parity bits as follows: the I/O shall generate and check parity of each 8 information bits of the data bus interface and on each 16 bit computer halfwords of the mass memory interface. In addition to the parity checks, lack of a response from a device shall be detected. The I/O shall wait (TBD) microseconds for the response. If any malfunction is detected in the I/O, the CPU shall be interrupted, and the transfer terminated.

3.7.9.2.4.2 Serial channels. The serial channel interfacing with the data bus shall have five independently enabled drivers and receivers under program control such that any one (or number) driver can be enabled and any one receiver can be enabled. The serial channel to the mass memory shall have three driver/receiver pairs, one for each of three mass memories. Only one of the memories shall be used at a time. Identification of the mass memory in the transfer initialization instruction shall automatically select the driver/receiver.

3.7.9.2.5 Mass memory unit. The MMU shall include the storage medium and electronics to decode the commands and addresses to access the drum area and to store or read at the proper intervals. The MMU shall be capable of storing a minimum of 15 million bits.

3.7.9.2.5.1 Readout. Data readout shall be non-destructive. Data once written shall not be degraded or changed by other than write operations. The MMU shall not have more than one error for every (TBD) bits read.

3.7.9.2.6 Digital data bus. The data bus shall consist of three functional areas: 1) the transmission lines themselves; 2) acquisition, control, and test (ACT) units; and 3) line coupling units. The I/O portion of the DCM computer shall contain the logic to perform as a bus control unit. The DCM computer shall have complete control of the data bus and no data or command shall go on the bus unless generated by or specifically requested by the DCM computer. The data bus shall operate in a half duplex mode with the signals generated by the I/O portion of the DCM computer on one transmission line, and those generated by any of the vehicle subsystems functional elements on another line. Simultaneous transmission in both directions shall not be used. The data bus shall:

a. Distribute data at a 1 MHz bit rate.

b. Be able to accommodate 254 interface devices (ACT's).

c. Be able to handle analog, discretes, and serial digital data both ways on the bus. Interface details shall be as shown in paragraph 3.7.9.1.

d. Provide a means to ensure that control signal outputs fail in a system safe mode.

e. Provide a means to ensure that control signal outputs assume a preferred state during subsystem initialization (power up) and standby operation.

f. Provide a low power standby mode in the ACT's to minimize power consumption when the ACT's are not being addressed or commanded.

g. Provide the capability of driving 300 feet of transmission line down each side of the booster vehicle.

3.7.9.2.7 Fault tolerance. The level of fault tolerance shall be a fail-operational/fail-operational/fail-safe hybrid failure concept. The time required for DCM subsystem fault detection and recovery shall be no more than (TBD) milliseconds.

3.7.9.3 Physical characteristics. The DCM subsystem shall have the general size, weight and volume as described in 3.2.3 herein.

3.7.10 Displays and controls. The displays and controls (D&C) subsystem, in conjunction with the data and control management (DCM) subsystem, shall provide the devices for operation and checkout of the booster. Command access shall be provided for all functions essential to flight and personnel safety. The flight crew shall have provisions to intervene and command the vehicle to a safe state, if malfunctions or contingency situations occur. Separate, guarded arming/enabling controls shall be provided for critical functions where the effect of inadvertent initiation would be hazardous or irreversible. Real-time readout of information essential to flight crew operations shall be provided via visual displays. The subsystem shall be capable of calling up data required to effectively manage the mission, the vehicle, and its subsystems. This data includes consumables information, configuration data, and status parameters available for display to the flight crew. No-go condition information shall be displayed via an alarm system, which shall inform the flight crew of caution, warning, or emergency situations and identify problem location to facilitate further investigation. The D&C subsystem shall provide a fail operational/fail safe hybrid failure concept with switch-out of the functioning functional path by the DCM subsystem. The checkout and fault isolation capability of the DCM subsystem shall be used to operationally check and to isolate fault in the D&C subsystem. The D&C subsystem shall be capable of performing the following functions:

a. Accept data from the DCM subsystem, generate and display alphanumerics, special symbols, and vectors representative of actual/predictive vehicle flight dynamics and booster subsystems status without objectionable flicker.

b. Accept crew initiated key/switch signals and convert, format, process, and route to the DCM subsystem.

c. Accept crew initiated numeric key signals and convert, process, and display messages prior to DCM computer entry.

d. Route caution and warning alarm and status signals to the status displays and to a master caution and warning display which will project messages, highlighted by the use of color.

e. Generate an audio signal to attract crew attention during emergency and malfunction indications.

f. Provide the manual flight controls for vehicle flight control and maneuvering.

g. Provide display panel lighting and control.

3.7.10.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems as shown in Figure 3.7.10.1-1 and described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2. The D&C subsystem interface with other booster subsystems shall be accomplished via the data and control management subsystem and its associated data bus.

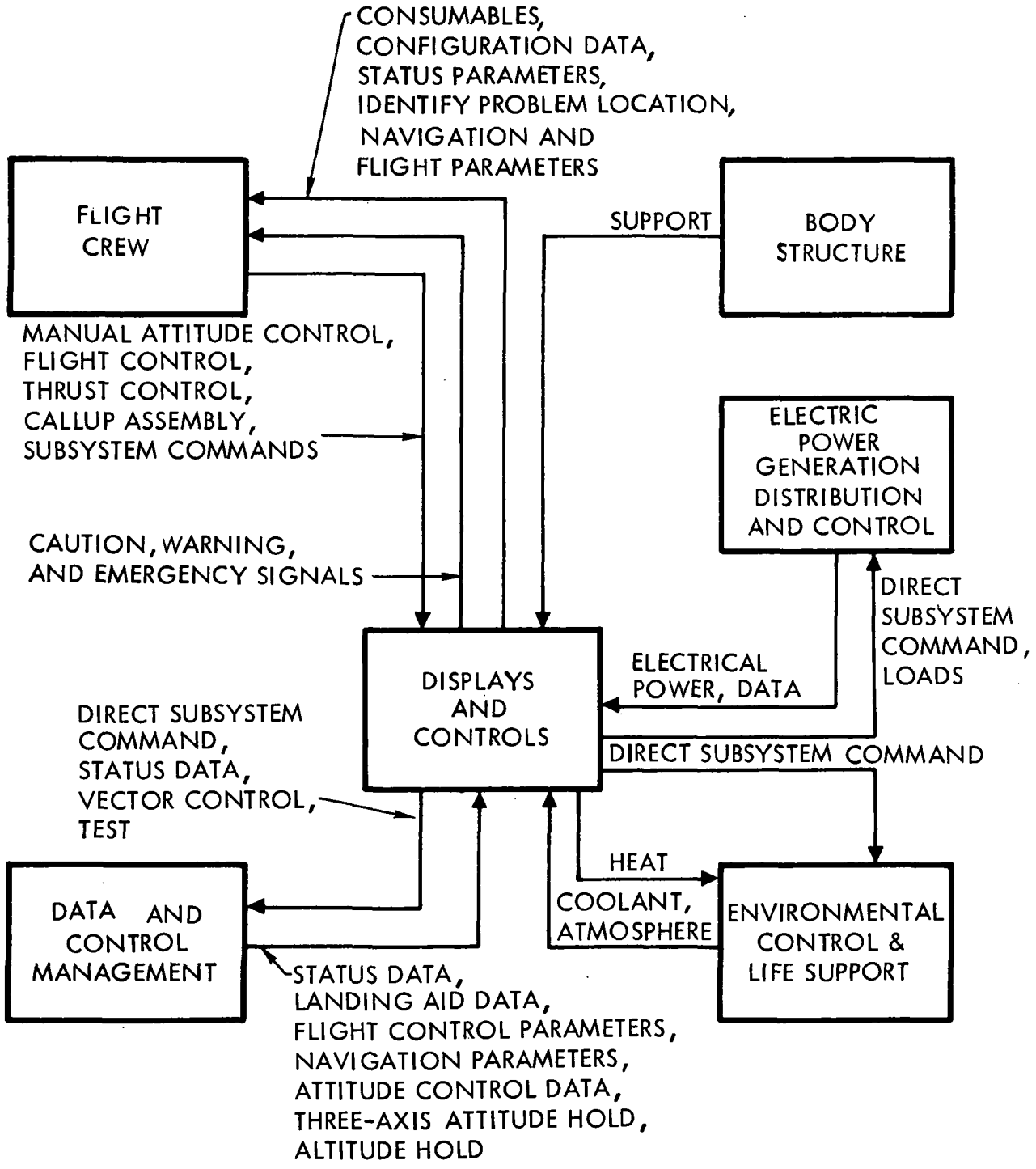


Figure 3.7.10.1-1. Block diagram of interfaces with displays and controls subsystem

Subsystem	Performance Paragraph of this specification
Body structure	3.7.1.2
Data and control management	3.7.9.2
Electric power generation, distribution, and control	3.7.14.2
Environmental control and life support	3.7.15.2

3.7.10.2 Performance

3.7.10.2.1 Conditions for performance. TBD

3.7.10.2.2 Multiformat cathode ray tube (CRT) displays. A set of multiformat CRT displays shall interface with the DCM computer and, by means of logic, shall enable the display of DCM computer processed data in accordance with the manual or automatic selected mode. The CRT displays shall meet the following requirements:

a. The program stored in the display formatter shall be executed at a maximum repetition rate of (TBD) times per second.

b. The CRT displays shall be capable of accepting a minimum of (TBD) 32-bit variable data words with an update rate of (TBD) times per second.

c. Manual/automatic display select and mode control signals shall be routed, formatted, and transferred to the DCM subsystem as required.

d. The formatter storage shall be electrically alterable during flight as a result of a program(s) being loaded into display formatter storage from the DCM subsystem.

e. The contrast between any written information on any area of the face of the CRT and any area adjacent to the written information shall be at least (TBD).

f. The refresh rate of the display system shall be sufficiently high so as to produce no observable flicker at all conditions of display brightness settings and under all conditions of ambient illumination.

g. The X-ray radiation shall not exceed the levels specified in MIL-R-9673.

h. The loss or resolution with the filter in place shall be such as to be undetectable by a normal human eye when viewing the CRT at a distance of 30 inches within a 20 degree cone of vision.

3.7.10.2.3 Alphanumeric displays. A set of alphanumeric displays shall interface with the DCM system and display DCM computer processed data and crew numeric inputs. Numeric data entry, and controls for the selection of displays and control functions shall be provided. The alphanumeric displays shall meet the following requirements:

a. Data format shall be 12 lines of 20 characters each.

b. The constrast between any written information on any area of the face of the display and any area adjacent to the written information shall be at least (TBD).

c. There shall be no observable flicker at all conditions of display brightness settings and under all conditions of ambient illumination.

3.7.10.2.4 Time read out displays. Greenwich meantime (GMT) or mission elapsed time (MET) in (TBD) days, hours, minutes, and seconds as well as two of any four event time bases in minutes and seconds shall be simultaneously displayed.

3.7.10.2.5 Caution and warning system. The caution and warning (C&W) system shall monitor DCM as well as hardwire system analog and discrete measurements. The C&W shall compare these measurements with established limits, provide storage for retention of status for diagnostics and provide outputs to annunciator lamps and audio system for crew alert. The C&W display shall be capable of providing (TBD) read outs.

3.7.10.2.6 Control/display panels. All subsystem control and/or display panels shall be designed to provide commands to and accept data from the data bus of the DCM subsystem. The panels shall provide the means for selecting, controlling, monitoring and status checking the booster subsystems. Multipurpose controls shall be employed for all configuration and sequencing of operational subsystems by use of mode select panels and computer entry/control keyboards. In addition, dedicated controls shall be provided for critical functions essential to safe return.

3.7.10.3 Physical characteristics. The guidance, navigation, and control system shall have a general arrangement, size, weight, and volume as described in paragraph 3.2.2.

3.7.10.3.1 CRT displays. The viewable display size shall be at least (TBD) inches. All alphanumerics shall be 0.15 inch high and the width shall be 75 percent of their height. Manual entry controls shall be provided for the selection of displays and mode controls. No character or symbol shall contain a discontinuity or waviness in excess of (TBD) inch deviation from the continuous straight line segments of which the symbol is composed. A day filter shall be provided as an integral part of the display. When in place, the filter shall also act as an implosive mask to protect the operator from flying glass and the implosion of the display tube. A suitable absorption filter for night operation shall be provided to allow the pilot's retention of night-vision adaption.

3.7.10.3.2 Alphanumeric displays. The viewable display size shall be at least 4-1/2 inches by 4-1/2 inches and consistent with a minimum of (TBD) alphanumeric characters. Alphanumeric character size shall be 0.18 inch high by 0.13 inch wide. Character spacing shall be nominally 0.19 inch and line spacing shall be nominally 0.33 inch.

3.7.10.3.3 Caution and warning. The C&W system shall have (TBD) major indicator/annunicators, and shall provide the controls as required to acknowledge events, control audio signals, and interrogate booster subsystems status.

3.7.10.3.4 Manual flight controls. The primary manual flight controls shall include two 3-axis, side-stick type rotation controllers for attitude and maneuver commands; two pedal assemblies for control of rudder, nosewheel steering, and wheel brakes; and a centrally mounted throttle quadrant for air-breathing engines. Secondary controls located on the flight deck shall include landing gear, parking brake, communications controls, and crew audio control. A generally symmetrical crew station arrangement shall be provided for vehicle control, so that the vehicle can be flown from either seat in the event of flight emergency situation.

3.7.11 Communications. The communications subsystem, in conjunction with its associated displays/controls and the data and control management (DCM), subsystem, shall be capable of providing voice communications, navigation/landing aids and hardwire data link to the orbiter for the operation of the Space Shuttle. The communications subsystem shall provide a fail operational/fail safe hybrid failure concept with switchout of the malfunctioning functional path via the DCM subsystem. The checkout and fault isolation capability of the DCM subsystem and the crew shall be used to operationally check and to isolate faults in the communication subsystem. The communications subsystem shall consist of UHF/AM voice and down data link, L-band air traffic control (ATC) link, precision ranging system, radar altimeter, recovery beacon, booster/orbiter hardwire data link and intercommunications system. The switching of the receiving and transmitting functions shall be controlled by the DCM computer with manual override capabilities. The precision ranging system, augmented with a radar altimeter, shall provide the required data for approach and landing. The L-band ATC link shall be used for identification and altitude information. The communications subsystem shall be capable of performing the following functions:

a. Provide voice intercom between booster crew members and between booster and orbiter crews (while mated and limited post-separation period).

b. Provide two-way simplex voice communications between booster and ATC stations.

c. Provide two-way hardwire data capability between mated booster and orbiter.

d. Provide identification signals to FAA navigational and ATC facilities upon receipt of proper interrogation signal.

e. Provide landing aids capability to furnish altitude, range, and lateral guidance data to support manual and automatic booster landings.

f. Provide recovery radio beacon capability to guide search operations in the event an emergency occurs.

g. Provide limited down data capability to launch site.

h. Provide a flight log recorder to record pertinent data preceding an emergency.

3.7.11.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems as shown in Figure 3.7.11.1-1 and described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2. The communications subsystem interface with the displays and controls shall be accomplished via the DCM subsystem and its associated data bus.

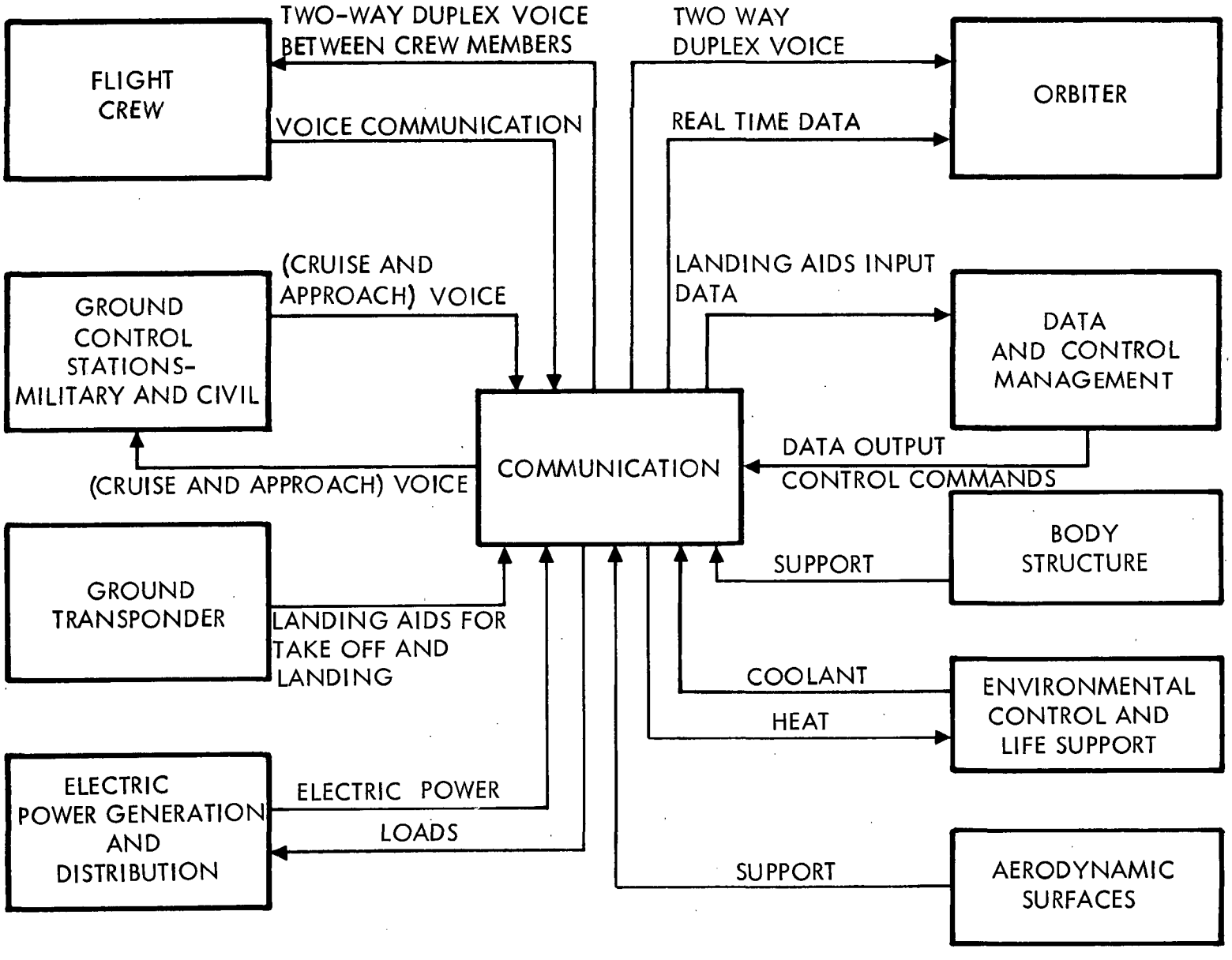


Figure 3.7.11.1-1. Block diagram of interfaces with communication subsystem

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Aerodynamic surfaces	3.7.2.2
Data and control management	3.7.9.2
Electric power generation, distribution, and control	3.7.14.3
Environmental control and life support	3.7.15.2

3.7.11.1.1 Standard ACT/select buffer interface. The data interface with the DCM subsystem shall have the following characteristics:

Operating mode	TBD
Line impedance	(TBD) ohms
Signal levels	(TBD) volts
Type signal	TBD
Data rate	(TBD) bps
Method of controlling signal transfer	TBD

3.7.11.2 Performance

3.7.11.2.1 Conditions for performance. TBD

3.7.11.2.2 Mated operations. Certain selected data shall be transferred between the booster and orbiter vehicles. The data to be transferred is serial data from the DCM subsystem via the standard ACT/select buffer interface described in 3.7.11.1.1. The booster crew shall be able to communicate with the orbiter crew via four shielded twisted pairs in the booster/orbiter hardwire umbilicals. These voice and data link paths shall have the following characteristics:

	Voice	Data link
Operating mode	Duplex	TBD
Voice bandwidth	300-3000 Hz	----
Input/output impedances	(TBD) ohms	(TBD)ohms
Signal level	(TBD) db	(TBD)db
Type of signal	----	TBD
Data rate	----	(TBD) bps
Method of controlling signal transfer	----	TBD

3.7.11.2.3 Communication after separation. The communication between vehicles after separation shall be via the UHN/AM voice link. The characteristics shall be as follows:

Carrier frequency	225 to 400 MHz
Operating mode	Simplex
Voice bandwidth	300-3000 Hz
Modulation	AM
Minimum operating range REF	(TBD) n.mi.
Radiated signal strength	TBD

3.7.11.2.4 Booster to air traffic control (ATC) network. The communication subsystem shall be capable of voice communication with the ATC stations during periods of aerodynamic flight. The characteristics of the UHF/AM link shall be as described in 3.7.11.2.3. The subsystem shall provide identification and altitude signals to navigational and air traffic control stations. The characteristics shall be as follows:

Receive frequency	1030 MHz
Transmit frequency	1090 MHz
Minimum line of sight range REF	(TBD) n.mi.
Radiated signal strength	TBD

3.7.11.2.5 Booster to ground transponder. A precision ranging system shall be capable of interrogating cooperative ground transponder for the purpose of determining range and range rate data. The characteristics of this system shall be as follows:

Receive frequency	(TBD) MHz*
Transmit frequency	(TBD) MHz*

*Note: The above frequencies shall be in the range of 2000 to 2100 MHz.

Modulation	TBD
Ranging signal characteristic	TBD
Addressing technique	TBD
Range accuracy	TBD
Range rate accuracy	TBD
Minimum operating range	TBD
Maximum operating range	TBD
Maximum range rate	TBD

3.7.11.2.6 Landing aid. The communication subsystem shall be capable of measuring the distance to the ground surface. The characteristic of the radar altimeter shall be as follows:

Operating frequency	4100 to 4300 MHz
Minimum operating altitude	Touchdown
Maximum operating altitude	TBD
Altitude error	TBD

3.7.11.2.7 Flight log recorder and recovery beacon. A crash type data and voice recording capability and radio beacon capability which have a high probability of surviving atmospheric emergency conditions shall be provided. The recording system shall have the following characteristics:

Number of voice channels	TBD
Data rate	TBD
Type data	TBD
Duration of loop recording	(TBD) minutes

a. The data to be recorded will be formatted and transferred to the flight log recorder by the DCM subsystem via the standard ACT/select buffer interface described in 3.7.11.1.1.

b. The recovery beacon shall transmit a signal which acts as a beacon for search operations. The beacon shall have the following characteristics:

Transmit frequency	243 MHz
Modulation	TBD
Radiated signal strength	TBD

3.7.11.3 Physical characteristics. The communications subsystem shall have the general size, weight and volume as described in 3.2.3 herein.

3.7.12 Auxiliary power unit. The auxiliary power unit (APU) shall generate the mechanical energy required for other subsystems shown in Figure 3.7.12-1 and shall provide shaft power for hydraulic and electric power generation during preflight and flight operations.

3.7.12.1 Interfaces. This subsystem shall interface with the support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2 herein.

Subsystem	Performance paragraph of this specification
Aerodynamic surfaces	3.7.2.2
Attitude control propulsion	3.7.6.2
Data and control management	3.7.9.2
Hydraulic power generation, distribution, and control	3.7.13.2
Electric power generation, distribution, and control	3.7.14.2

3.7.12.2 Performance

3.7.12.2.1 Conditions for performance. The auxiliary power unit shall be capable of operation when provided with:

	Pressure (psig)	Temp (° R)	Regulation
GH_2	TBD	TBD	TBD
GO_2	TBD	TBD	TBD

3.7.12.2.2 Power demand. The auxiliary power unit shall be capable of supplying power with the following characteristics to a demand not greater than that specified:

Hydraulic power input shaft	Electric power input shaft
Speed TBD rpm ± TBD rpm	See 3.7.14.1.1 and 3.7.14.1.1.1
Horsepower (max demand) TBD	

3.7.12.2.3 Control equations. TBD

3.7.12.2.4 Control of performance. The auxiliary power unit shall be capable of automatic control of operation with response characteristics as follows:

Speed control (load conditions)	TBD
Speed control, (no load condition)	TBD

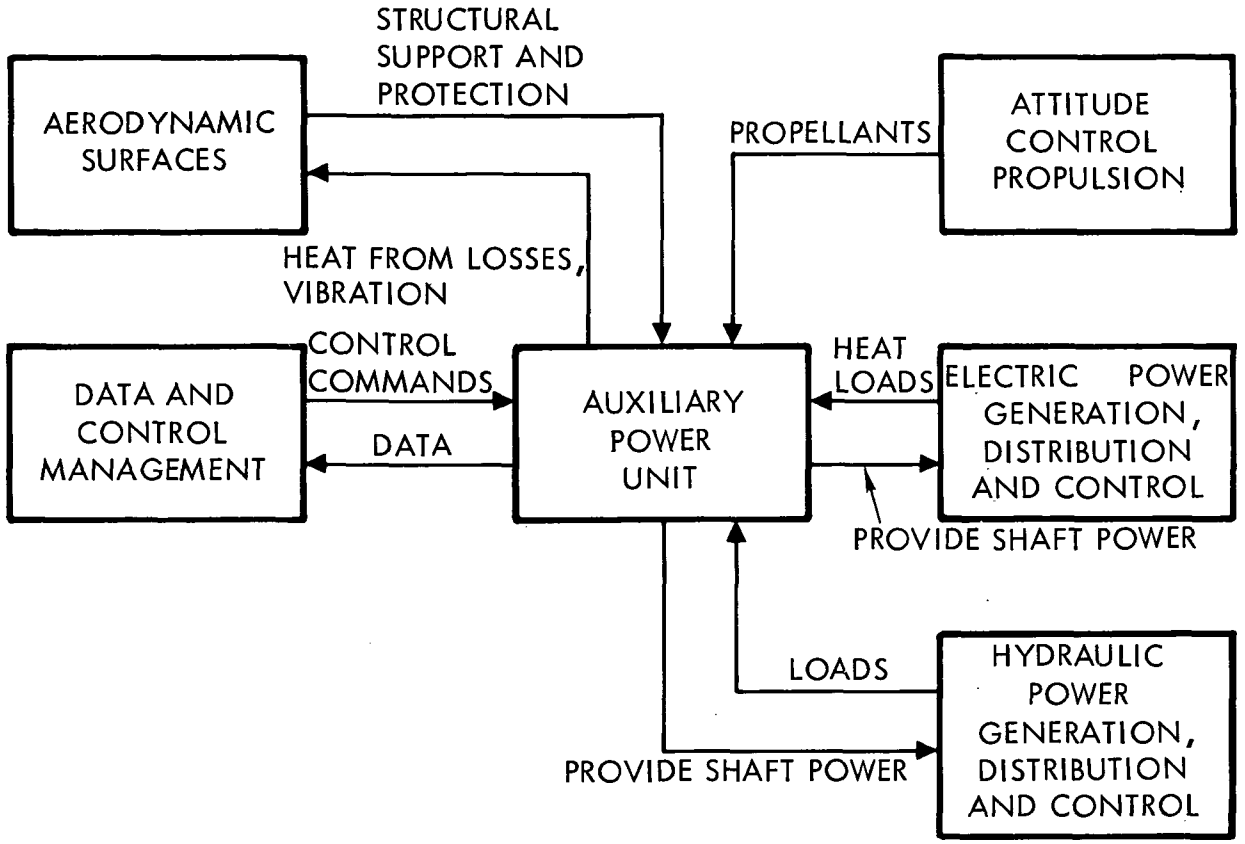


Figure 3.7.12-1. Block diagram of interfaces with auxiliary power unit subsystem

3.7.12.3 Physical characteristics. The auxiliary power unit shall have the general size, weight and volume as described in paragraph 3.2.2.

3.7.12.3.1 Self-cooling features. The auxiliary power unit shall be provided with self-cooling features.

3.7.13 Hydraulic power generation, distribution and control. The hydraulic power generation, distribution, and control system shall be capable of providing hydraulic power and other functions shown in Figure 3.7.13-1.

3.7.13.1 Interfaces. This subsystem shall interface with the ground support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Aerodynamic surfaces	3.7.2.2
Landing system	3.7.4.2
Main propulsion	3.7.5.2
Air breathing propulsion	3.7.7.2
Data and control management	3.7.9.2
Auxiliary power unit	3.7.12.2
Electrical power generation, distribution, and control	3.7.14.2

3.7.13.2 Performance characteristics

3.7.13.2.1 Conditions for performance. The performance of the hydraulic system shall be based on the following conditions:

TBD

3.7.13.2.2 Actuator loads and rates (aerodynamic surfaces). The hydraulic system shall be capable of movement of the aerodynamic surfaces at the loads and rates specified in Table 3.7.13-2 during the flight phases specified in 3.2.1.1.3 through 3.2.1.1.8 and 3.2.1.2.

3.7.13.2.3 Actuator loads and rates (landing gear). The hydraulic system shall be capable of movement or actuation of the landing gear at the loads and rates specified in Table V during the flight phase specified in 3.2.1.1.6, 3.2.1.1.7 and 3.2.1.2.2.

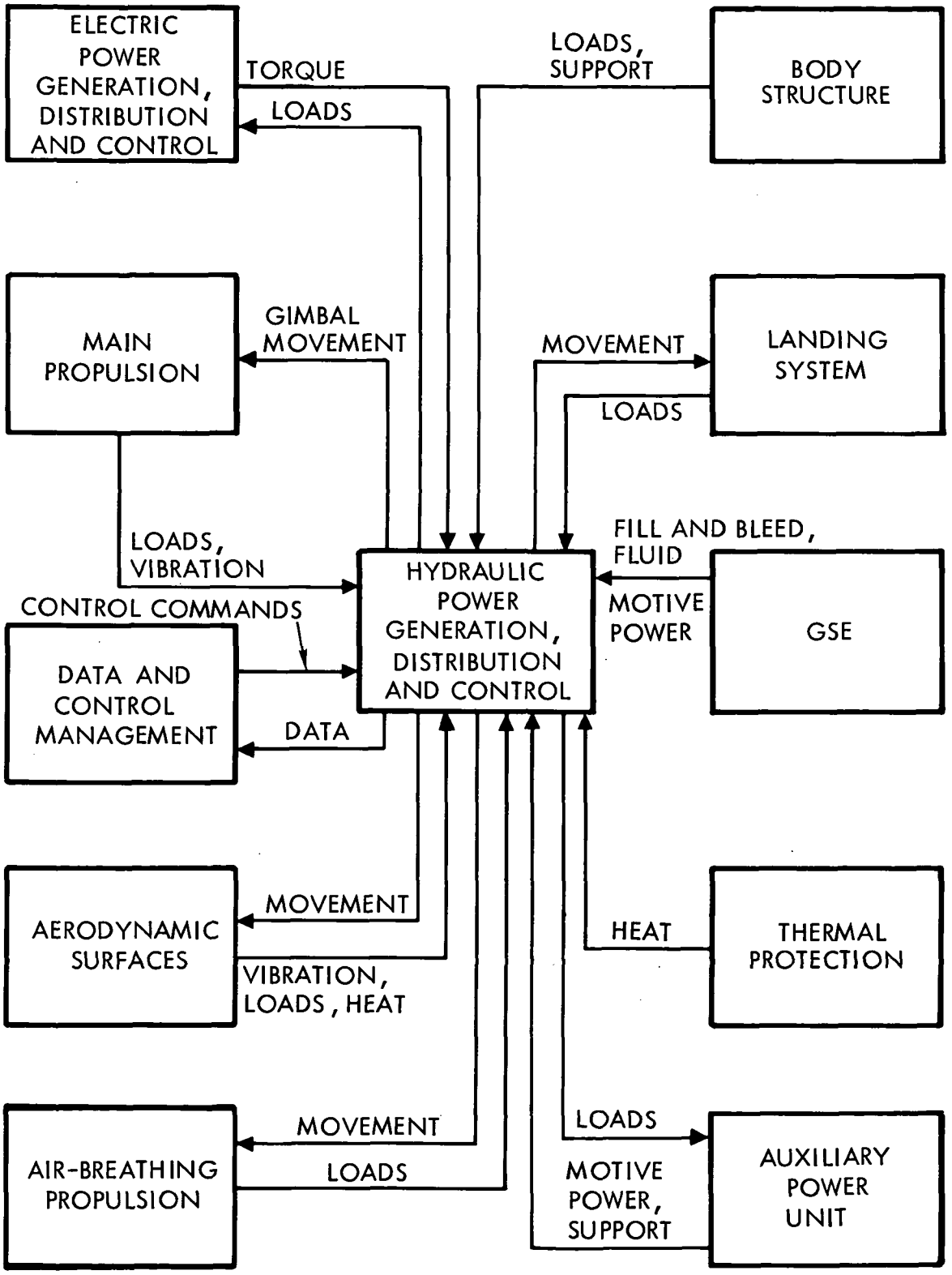


Figure 3.7.13-1. Block diagram of interfaces with hydraulic power generation, distribution and control subsystem

3.7.13.2.4 System flush and refill. The design of the system shall be such that it can be drained, flushed, refilled, bled, and pressurized for service in 30 minutes or less.

3.7.13.2.5 Actuation loads and rates (airbreathing engines). The hydraulic system shall be capable of deployment of the airbreathing system in 30 seconds during the flight phase specified in 3.2.1.1.3 with loads and rates as specified in Table III.

3.7.13.2.6 Actuation loads and rates (main engines). The hydraulic system shall be capable of supplying power for movement or actuation of the main engines during the flight phase specified in 3.2.1.1.1 and 3.2.1.1.2 with the loads and rates as specified in Table V.

3.7.13.3 Physical characteristics. The hydraulic system shall have the general size, weight and volume as described in paragraph 3.2.2 herein.

3.7.13.3.1 Reservoir. The hydraulic system shall be capable of retaining TBD gallons of hydraulic fluid at TBD psig.

3.7.13.3.2 Fill and bleed provisions. TBD

3.7.13.3.3 System fluids. The system fluid shall not require changing at intervals sooner than 25 flights consisting of any combination of vertical and horizontal flights.

3.7.13.3.4 Operations and leakage. The hydraulic system shall be capable of being checked for leaks and to provide a power source to any system without connecting to a ground hydraulic source, and shall not require the confines of a hazardous area during these operations.

Table V. Hydraulic System Performance Data

Function	Travel - Surface, Gimbal, or Mechanism (deg)	Hinge Moment (ft-lb)	Rate (deg/sec)	Operating Time (sec)	Degradation After Two Failures
TVC/ axis/ engine	±10	165,000 *110,000	0 10		10 engines gimbaling
Elevons/ side	±30	880,000 0	2 20		None
Rudder	±25	80,000 0	0 30		67% H. M.
Canards/	+30, -60	139,000 0	5 10		None
Engine deploy- ment/Eng	180	33,300		10	10 engines deployed
Main Gear					
Retract	106	310,000 each		15	
Extend				15	None
Nose Gear					
Retract	122	76,000		15	
Extend				15	None
Brakes	—	—	—	—	None
Steering	TBD	—	TBD	—	Return to neutral

* Inflight load only, actuator must meet start transient of 425,000 ft-lb per ICD 13M15000B.

3.7.14 Electric power generation, distribution and control (PGDC). The booster PGDC subsystem shall be capable of providing power generation, conversion, distribution, and control elements required to supply electric power of the types, quantities, and quality necessary to operate the utilization subsystems and their electrical, electronic, or electromechanical components as shown in Figure 3.7.14-1. The PGDC subsystem shall provide the following functions:

a. Distribution of all generated and converted forms of ac and dc power from source terminals to load terminals.

b. Generation, regulation, and control of primary ac power.

c. Conversion of primary ac power to dc secondary power.

d. Provisions for and control of secondary batteries.

e. Protection of buses and distribution circuits against failures of power source and grounding/overload faults.

f. Exterior lighting and interior compartment lighting.

g. Interconnection of GSE power source and controls to booster subsystems.

h. Redundant functional components in support of a FO/FS-hybrid failure concept, with switchout of the malfunctioning functional path by the DCM subsystem.

i. Completely automatic fault and failure sensing, control, and distribution system management.

j. Completely automatic, un-manned system start-up provisions.

3.7.14.1 Interfaces. This subsystem shall interface with the support equipment and with those subsystems described in the paragraphs referenced below. The PGDC subsystem interfaces with the mechanical power and utilization subsystems shall be as described herein.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Main propulsion	3.7.5.2
Air-breathing propulsion	3.7.7.2
Attitude control propulsion	3.7.6.2
Guidance, navigation and control	3.7.8.2
Data and control management	3.7.9.2
Displays and controls	3.7.10.2
Communications	3.7.11.2
Auxiliary power unit	3.7.12.2
Hydraulic power generation, distribution, and control	3.7.13.2
Environmental control and life support	3.7.15.2

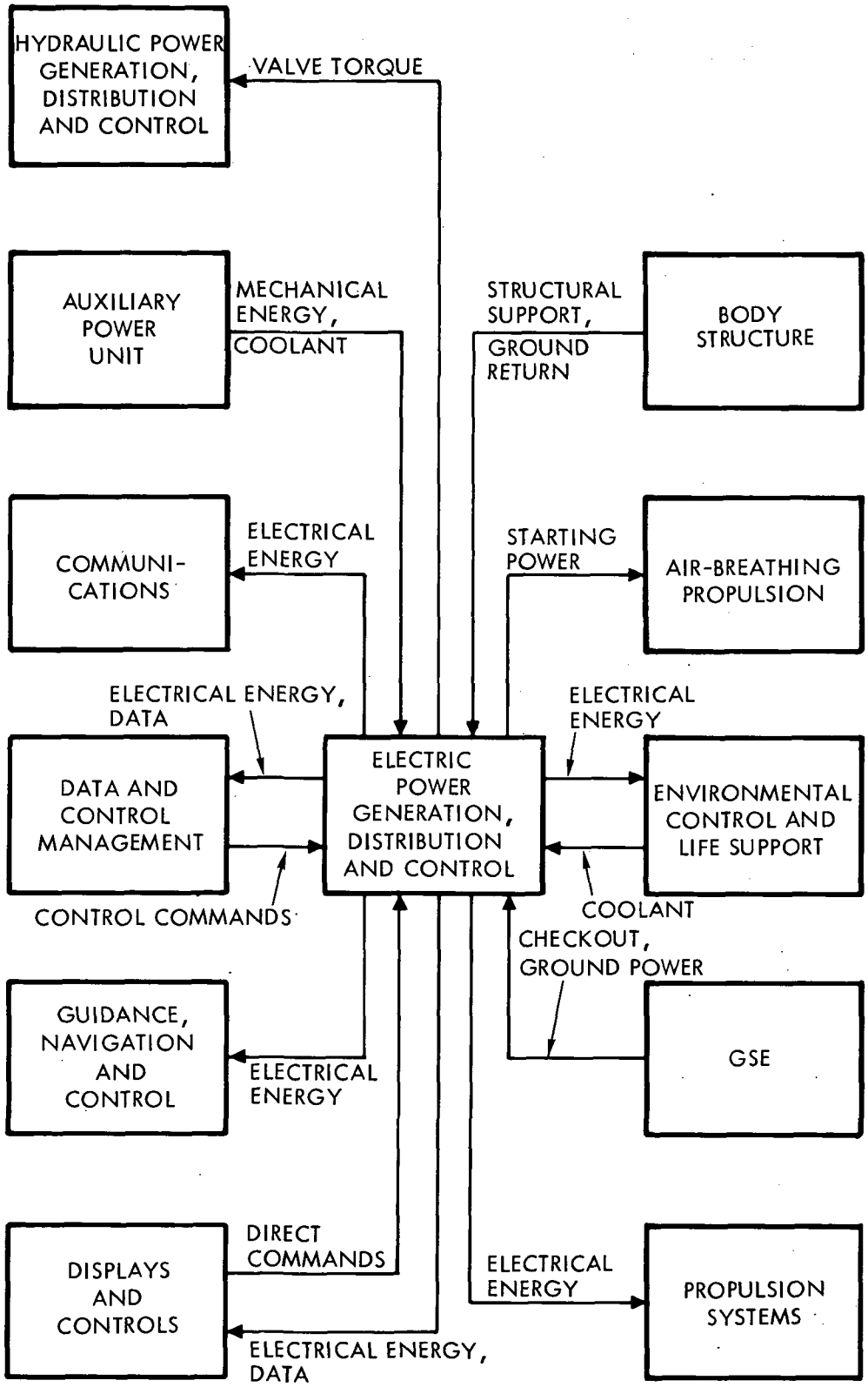


Figure 3.7.14-1. Block diagram of interfaces with electric power generation, distribution, and control subsystem

3.7.14.1.1 APU subsystem. The PGDC subsystem requires mechanical power to drive four ac generators. The drive sources shall be independent, except for speed synchronization control, and shall have the following characteristics:

Shaft speed	12,000 rpm ± 600 rpm
Variation in speed among the 4 shafts	30 rpm
Nominal mechanical load	48 hp
Maximum mechanical load (5 sec duration)	63 hp

3.7.14.1.1.1 Coolant. The drive source shall provide cooling oil to the generators. The coolant system shall have the following characteristics:

Type of oil	TBD
Minimum flow rate	6 gpm
Pressure	TBD psia
Maximum inlet temperature	125° F

3.7.14.1.1.2 Synchronizing signals. The PGDC subsystem shall provide four speed synchronization signals to the drive subsystem speed trim control. The signals, one per generator channel, shall be nominal 115-volt, L-N, 400 Hz signals having the characteristics defined in paragraph 3.7.14.2.2.1.

3.7.14.1.2 Utilization Subsystems

3.7.14.1.2.1 Remote power controller interface. The PGDC subsystem interfaces with the electric power utilization subsystems shall be at the subsystem LRU connectors. Electric power having the characteristics defined in 3.7.14.2 shall be supplied from a distribution bus, through a remote power controller (RPC), to the unit connector. The RPC shall provide the following functions:

a. Remote control of power application to or removal from the subsystem LRU.

b. Overload current sensing and automatic, trip-free removal of power from the load.

c. Trip signal indication to the control ACT.

d. Remote reset capability.

e. A backup, non-resetable fault clearing capability that does not provide a trip indication.

The RPC functional characteristics shall be:

*Trip time	TBD

*Trip current	TBD
Operating power	5 vdc 10 ma
Input impedance	TBD ohms
Trip signal	5 vdc 10 ma
Operating time	TBD ms
Back-up current limit	TBD % nominal rating

*Sensing logic shall provide inverse or fixed time delay depending on the current-time characteristics of the load.

3.7.14.1.2.2 Data and control management (DCM) interface. The PGDC subsystem interface with the DCM shall include, in addition to those described above, the following functions:

a. The PGDC subsystem signals requiring measurement, monitoring, storage, or display shall be delivered to the input connector of an ACT. (Specific signals with their characteristics and required sampling rates are listed in the Booster Vehicle Signal List.)

b. The PGDC subsystem shall receive command control signals from the DCM for bus management in the event of PGDC failures or faults or for normal configuration changes. The following are included:

Ac bus-tie contactor

Dc line contactor

Battery line contactor

(See Booster Vehicle Signal List for detailed characteristics).

3.7.14.1.2.3 Displays and controls (D&C) interface. The PGDC subsystem interface with the D&C shall include the following functions in addition to those described above in paragraph 3.7.14.1.2.1.

a. The PGDC subsystem shall receive manually switched control signals from the D&C for subsystem start-up and configuration control when operating in the manual mode. The following are included:

Ac generator/generator line contactor

Ac bus-tie contactor

External power

Battery

Transformer-rectifier/dc line contactor

Dc bus-tie contactor

(See Booster Vehicle Signal List for detailed characteristics.)

b. The PGDC subsystem shall provide (via the DCM subsystem) the following signals to be displayed on the caution and warning panel:

Ac generator off

TR off

Generator oil over temp

Generator main bearing failure

Transfer bus on

3.7.14.1.2.4 Environmental control and life support system interface. The ambient operating environment required by the PGDC subsystem shall be provided by the EC/LSS. Except for the ac generators, which shall be oil-cooled as described in 3.7.14.1.1, all PGDC components shall be provided with an ambient environment having a nominal temperature within the limits of -55° F to +150° F when the equipment is functioning and dissipating heat in accordance with the data shown by Table (TBD). Temperature transients beyond these limits (time and temperature TBD) are permitted.

3.7.14.1.3 Structure interface. The vehicle structure shall provide the support required for PGDC components and wiring and shall in addition provide the ground return path for all electric power. The electrical resistance of the structure shall have the following maximum value:

TBD

3.7.14.1.4 Ground support equipment (GSE) interface. The PGDC subsystem shall receive from the GSE subsystem during groundborne operation of the booster, ac electric power having the same characteristics as those defined for the airborne system in 3.7.14.2.1. The interface with GSE shall be at an ac external power receptacle of the type defined by AN3114-2A. The rated capacity of the external power source shall be not less than TBD KVA at 0.75 to unity power factor. Regulation, control, and fault protection functions simular to those of the PGDC subsystem will be provided by the GSE power source. In addition, the GSE will provide a capability to self test its phase rotation at the mating connector prior to connection to the booster vehicle and the point of voltage regulation shall be at the GSE-vehicle interface.

3.7.14.2 Performance characteristics

3.7.14.2.1 Conditions for performance. TBD

3.7.14.2.2 Power generation

3.7.14.2.2.1 Ac power characteristics. Ac electric power with the following characteristics shall be provided at the ac load interfaces:

Phases	3, 120 degrees displacement
Nominal voltage	115 v L-N, 200 v L-L
Steady stage limits	109-117 v L-N
Transient limits	(See Figure 3.7.14.2-1)
Wave shape	Sinusoidal
Nominal frequency	400 ± 20 Hz
Synchronization	1 Hz

3.7.14.2.2.2 Dc power characteristics. Dc electric power with the following characteristics shall be provided at the dc load interfaces.

Nominal voltage	28 v
Steady state limits	24 - 30 v
Transient limits	(See Figure 3.7.14.2-2)
Ripple voltage	4 v P-P (MIL-STD-704)

3.7.14.2.3 Power output. TBD

3.7.14.3 Physical characteristics. The electrical power generation, distribution and control subsystem shall have the general size, weight and volume as described in paragraph 3.2.2 herein. In addition, the PGDC subsystem shall provide all interconnecting hardwiring between LRU's of a given subsystem and between LRU's of different subsystems, including the harness connectors.

3.7.14.3.1 Power distribution and control

3.7.14.3.1.1 Ac distribution and control. The ac distribution and control elements shall provide:

a. Three, normally isolated, 3-phase bus systems normally fed from individual, non-paralleled ac generators.

b. De-energization and isolation of a faulted bus.

c. Isolation of a faulted or failed generator and subsequent re-energization of its bus from an operative machine.

d. Operation of all ac buses from a GSE power source.

e. System start-up independent of the DCM.

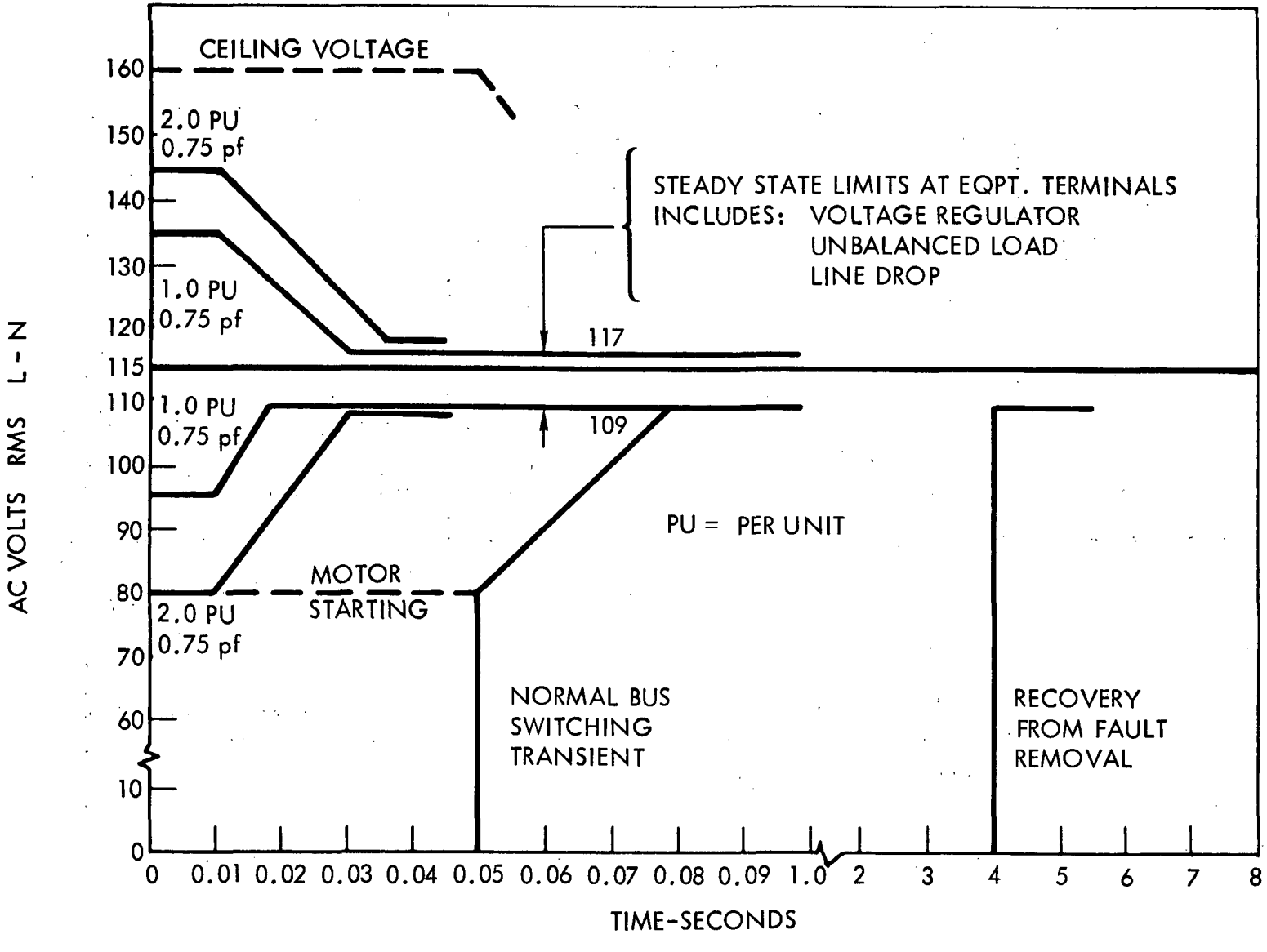


Figure 3.7.14.2-1. Ac transient and steady state voltage limits

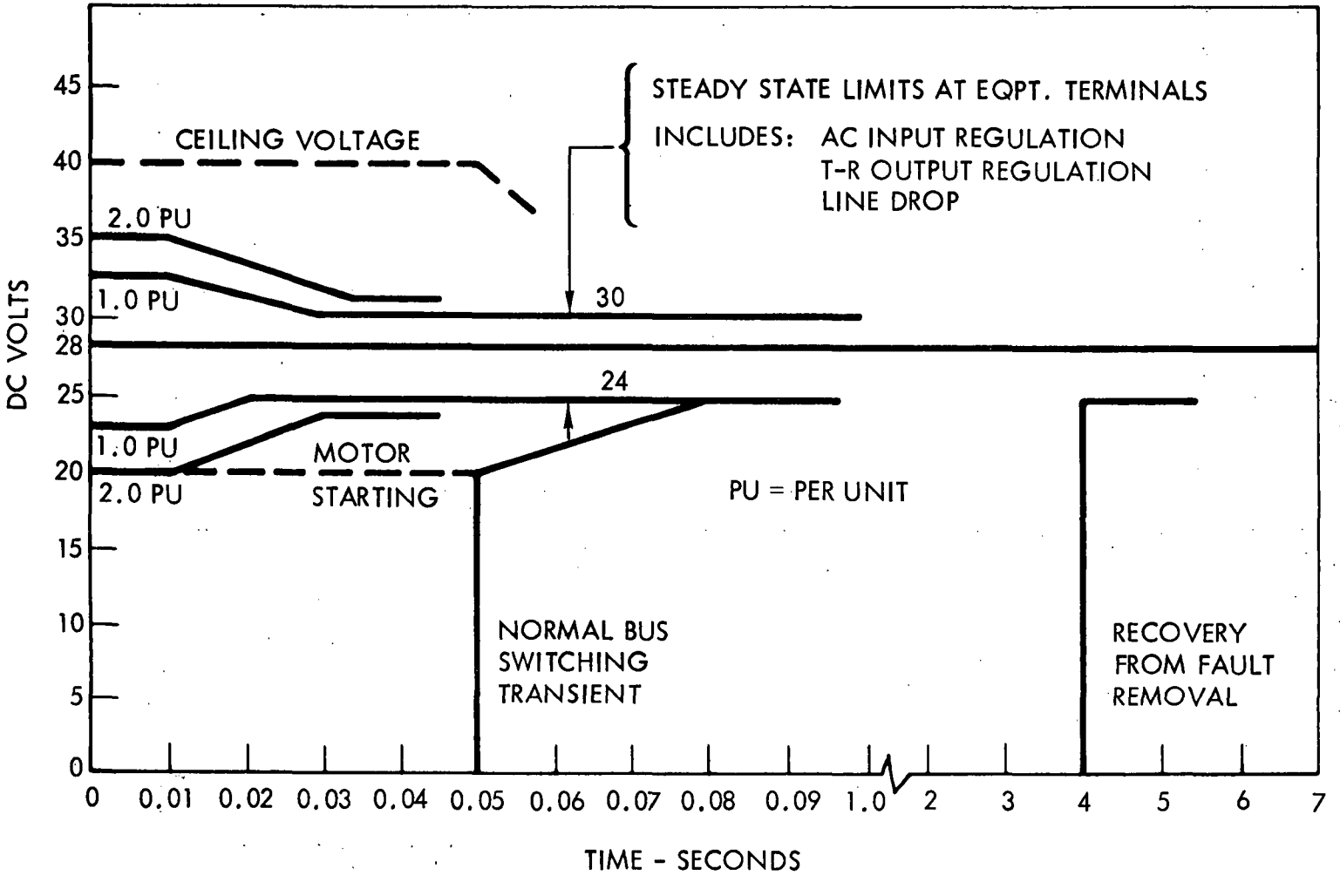


Figure 3.7.14.2-2. Dc transient and steady state voltage limits

3.7.14.3.1.2 Dc distribution and control. The dc distribution and control elements shall provide:

a. Six normally isolated buses (three forward and three aft) fed from individual transformer-rectifiers powered from the ac buses.

b. De-energization and isolation of a faulted bus.

c. Input and output isolation of a faulted or failed transformer-rectifier and subsequent re-energization of its bus from an operative unit.

d. Two auxiliary dc buses (one forward and one aft) capable of being supplied from the main dc bus or from a battery.

e. System start-up independent of the DCM.

f. On board conversion of ac ground-supplied power for dc buses.

3.7.14.3.2 Lighting. The PGDC subsystem shall provide exterior illumination for safe night operations, illumination of crew compartments, and adequate lighting in equipment compartments where night-time maintenance operations may be required. Display panel lighting shall be considered to be included in the controls and displays subsystem.

3.7.15 Environmental control and life support. The environmental control and life support system shall be capable of providing thermal control, humidity control, pressure control, and atmospheric control and other functions indicated in Figure 3.7.15-1.

3.7.15.1 Interfaces. This subsystem shall interface with the support equipment and with those subsystems described in the paragraphs referenced below. For detail descriptions of the interfaces with the equipment outside of this CEI, see the interface documents described in paragraph 3.1.2.

Subsystem	Performance paragraph of this specification
Body structure	3.7.1.2
Air-breathing propulsion	3.7.7.2
Guidance, navigation and control	3.7.8.2
Data and control management	3.7.9.2
Displays and controls	3.7.10.2
Communications	3.7.11.2
Electric power generation, distribution and control	3.7.14.2
Flight personnel provisions	3.7.16.2

3.7.15.2 Performance characteristics

3.7.15.2.1 Conditions for performance. TBD

3.7.15.2.2 Atmospheric output. The ECLS shall be capable of providing the atmosphere of the pressurized compartment as follows:

Normal conditions

Total pressure	11.4 to 14.7 psia
Cabin pressure differential	14.7 psi max
Partial pressure of O_2	2.4 to 3.1 psia
Partial pressure of CO_2	7.6 mm Hg max
Partial pressure of H_2O	12.0 mm Hg max
Crew station temp	65 to 80° F

3.7.15.2.3 Heat removal. The ECLS shall be capable of absorbing heat from personnel and equipment at the following rates:

Personnel	Continuous (Btu/hr)	Intermittent (Btu/hr)
Sensible	580	NA
Latent	620	NA

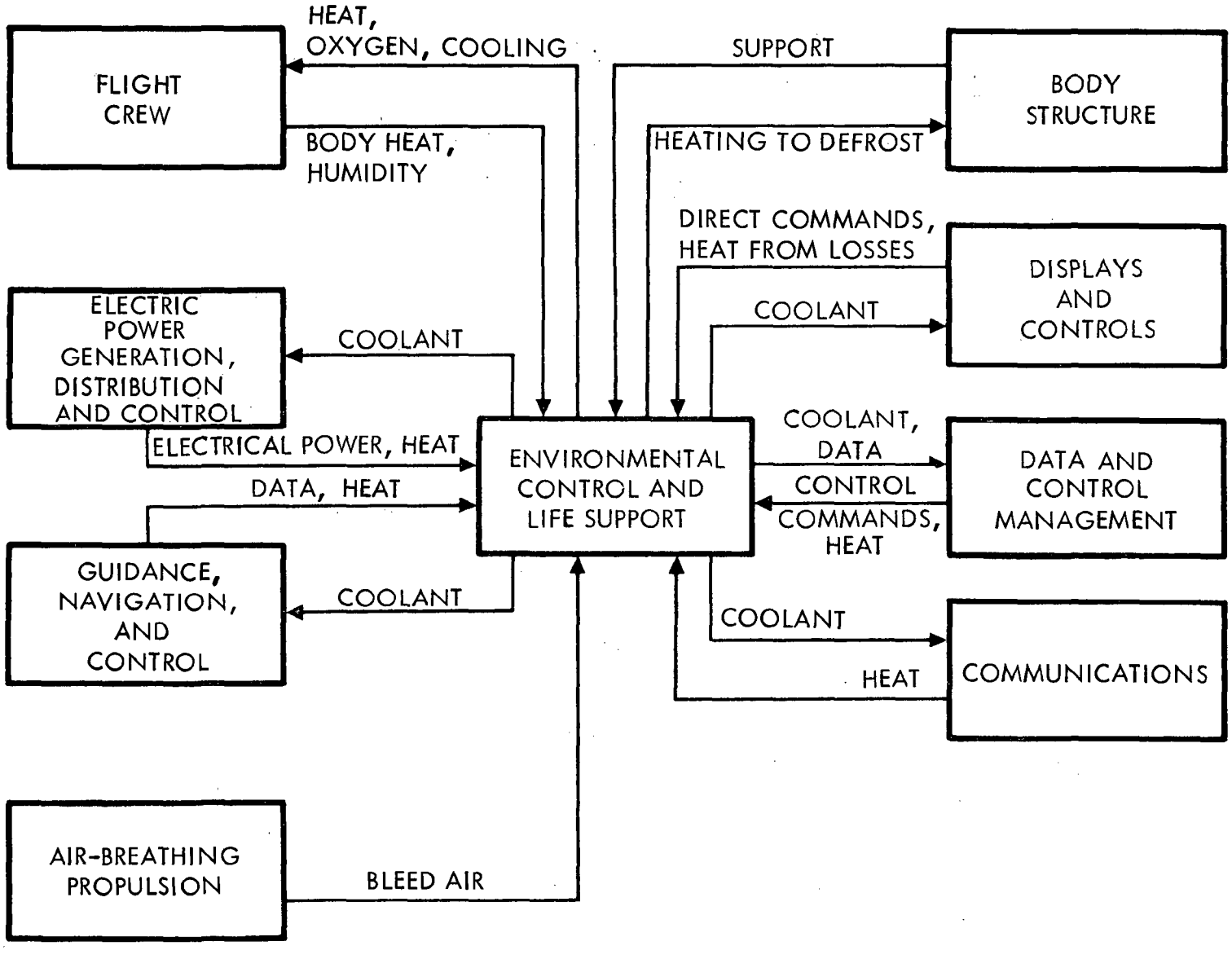


Figure 3.7.15-1. Block diagram of interfaces with environmental control and life support subsystem

	Continuous (Btu/hr)	Intermittent (Btu/hr)
Equipment	21,900	N/A
Structure	TBD	TBD

3.7.15.2.4 Emergency oxygen output. The ECLS shall be capable of providing emergency oxygen to the crew for 2 hours.

3.7.15.2.5 Heat supply. The ECLS shall be capable of supplying heat to avoid ice formation on the outer skin of the booster at the following rate: TBD

3.7.15.2.6 Control of performance. The ECLS shall be capable of manual or automatic control operation with response characteristics as follows TBD).

3.7.15.2.7 Checkout tests. The ECLS shall be capable of being tested for operational readiness within TBD minutes.

3.7.15.2.8 Purging. The ECLS shall be capable of distributing purging atmosphere (N_2) at the rate of 27.7 lb/sec at 160° F for (TBD) hours to maintain the levels of explosive mixture to within that specified in 3.3.1.1 herein and to prevent icing on the TPS for the 95 percent temperature, no wind condition.

3.7.15.2.9 Pressure control. The ECLS shall be capable of maintaining the pressure differential across the TPS to less than 2 psi.

3.7.15.2.10 Fire detection and extinguishing. The ECLS shall provide fire detection and a two-shot extinguishing capability for: APS, APU's, ABES, avionics, and crew station.

3.7.15.2.11 Visibility enhancement. The ECLS anti-ice, defog, washing and rain clearing capability shall meet the requirements of MIL-E-38453, MIL-R-81261, and MIL-W-7233.

3.7.15.2.12 Air distribution. The ECLS shall be capable of receiving and distributing air from the GSE and the air-breathing engines at the following rates and conditions:

Airflow	34 lb/minute
Temperature	1220° R max from ABES 40° F from GSE
Pressure	50 psig

3.7.15.2.13 Sanitary relief. The ECLS shall provide individual urine collection devices, for each crew member, capable of receiving urine at the rate of 4.48 pounds/man/day.

3.7.15.3 Physical characteristics. The environmental control and life support system shall have the general size, weight, and volume as described in paragraph 3.2.3.

3.7.15.3.1 Inert gas provisions. The ECLS shall provide for storage and distribution of on-board supplies of inert gases.

3.7.16 Flight personnel provisions. The flight personnel provisions shall be capable of providing the functions described in Figure 3.7.16-1. The subsystem shall be capable of providing the following functions:

a. Support of flight personnel during all flight modes.

b. Safe restraint during all flight maneuvers.

c. Protection of personnel from effects of acceleration.

d. Protection of personnel during water landing.

e. Aid to rescuers after emergency landing.

f. Supplying emergency oxygen to personnel during any ECLS malfunction.

3.7.16.1 Interfaces. This subsystem shall interface with the support equipment and subsystems described in Figure 3.7.16.1-1. For detail description of the interfaces with the equipment outside of this CEI, see the interface documents described in 3.1.2.

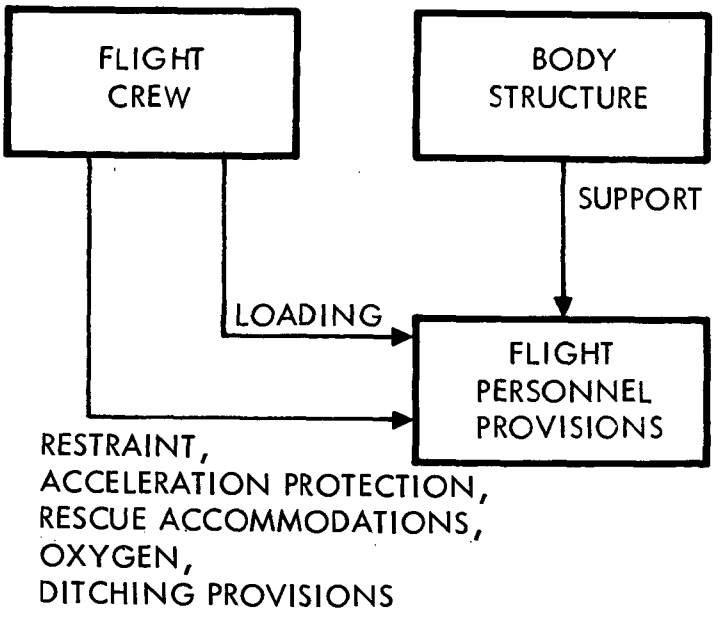


Figure 3.7.16-1. Block diagram of interfaces with flight personnel provisions

3.7.16.2 Performance characteristics. TBD

3.7.16.2.1 Conditions for performance. The flight crew provisions shall accommodate and safely restrain flight crew personnel in the range from 5th to 95th percentile in anthropometric size (projected to 1980 baseline). The crew seats and miscellaneous equipment shall permit adequate movement and visual clearance to realize the human performance required to satisfy the mission operational requirements.

3.7.16.2.2 Restraint of personnel. The subsystem shall be capable of safely restraining the flight personnel during any flight maneuver within the vehicle performance envelope, and during 20 g (forward loading) crash landing conditions.

3.7.16.2.3 Acceleration protection for personnel. The subsystem shall be capable of enabling flight crew personnel to safely withstand the normal acceleration (eyeballs down) encountered within the maneuver load limits of the booster vehicle, as specified in 3.2.5 for the mission flight phases.

3.7.16.2.4 Ditching. Flight personnel provisions shall be capable of deployment in case of water landings (ditching) within TBD minutes after egress has been cleared open. Such provisions shall be usable in TBD orientation on the water.

3.7.16.2.5 Rescue provisions. Flight personnel provisions shall be capable of signalling for rescue of the flight personnel within TBD minutes after egress has been cleared on land or TBD minutes on water ditching.

3.7.16.2.6 Emergency oxygen supply. The subsystem shall be capable of independently supplying emergency breathing oxygen to each pilot during all flight modes and any inflight emergency. Each (individual) emergency oxygen supply shall be capable of providing a 2-hour supply.

3.7.16.3 Physical characteristics. Each pilot will be provided with primary controls required for the manual control of the vehicle roll, pitch, and yaw axis. Location, size, weight, and operational limits of each control will be in accordance with the applicable specifications and standards describing the system operation and manufacturing interface. It shall have the general size, weight, and volume as described in paragraph 3.2.3.

3.8 Precedence

3.8.1 Documents. This specification shall take precedence over any documents referenced herein including the space shuttle system specification. All referenced documents shall be applicable only to the extent specified herein.

3.8.2 Design and performance. Requirements are identified below, listed in an approximate order of decreasing importance. The rank order indicated shall be considered only as a general criterion for design of the booster (CEI) and shall not be considered contractually binding.

1. Vehicle crew survival.
2. Vehicle mission success.
3. Vehicle total life cycle cost.
4. Cost per pound delivered into orbit.
5. Maximum payload capability.
6. Runway length required.
7. IOC dates.

4 QUALITY ASSURANCE PROVISIONS

4.1 General. The basic philosophy for performing the quality assurance provisions is based on progressive, incremental testing. The reusable nature of the shuttle system prime items, the orbiter vehicle, the booster vehicle, and the launch operations and services functional equipment allow this approach to be taken at a minimum program cost and with minimum risk to personnel or equipment. The booster vehicle will be tested as an individual item, first at test facilities and then at an operational facility. The severity of the flight environment will be progressively increased by increments until the maximum performance attainable by the booster vehicle is achieved. Test requirements in the preliminary test plan are structured to identify and accumulate data for key CEI subsystem paramcters throughout all phases of testing. These equipment, checkout procedures and data format and accumulation shall be standardized wherever possible. On-board checkout will be used for all testing at the subsystem level wherever practicable.

4.1.1 Responsibility for tests. Unless otherwise specified herein, the contractor shall be responsible for the performance of all testing requirements.

4.2 Quality conformance inspections. The following paragraphs cover the test/verification requirements necessary to determine that the requirements of Section 3 have been achieved. Any given Section 4 paragraph may provide verification requirements for all or part of the referenced Section 3 paragraph. Insofar as is practical, the tests are listed in a logical sequence. Appendix 20 delineates the verification method of each requirement.

4.2.1 Reliability testing. Test data collection and recording requirements will be reviewed for all system level tests. Test data that will be used as a part of the reliability analysis will be collected and recorded as required for system reliability verification purposes. Testing with the primary objective of obtaining reliability data will not be done unless this data cannot be obtained in the engineering tests and evaluations, the qualification tests, the installation tests, or formal performance verification tests and demonstrations. Tests identified as being required for reliability analysis only are listed in the following paragraphs.

4.2.1.1 Reliability tests. Not applicable.

4.2.2 Engineering test and evaluation. The test requirements specified in the following paragraphs are limited to those tests required for direct support of the design and development activity but that cannot be accomplished by testing performed at the configuration item level. In general, these are tests associated with the mated orbiter and booster launch and/or pre-launch activities conducted at the launch site. They also include the postflight activities.

4.2.3 Qualification testing. TBD

4.2.4 Installation testing. Installation testing of the booster vehicle at the system level will be accomplished as a part of the engineering test and evaluation requirements of paragraph 4.2.2 or the formal performance verification test and demonstration requirements of paragraph 4.2.5 to the greatest extent possible. Installation tests that cannot be met under these referenced paragraphs are listed in the following paragraphs.

4.2.4.1 Installation tests. Not applicable

4.2.5 Formal performance verification tests and demonstrations. The test requirements specified in the following paragraphs shall verify the performance and design requirements of Section 3. The test vehicle(s) used for these demonstrations shall be of operational configuration.

4.2.5.1 Assembly and launch of the booster. The operations necessary to show compliance with the paragraph 3.2.1.8 requirements for assembly and launch will be verified by the requirements in the following paragraphs.

4.2.5.1.1 Mating. The equipment, procedures and facilities required to erect the mated shuttle vehicle as a unit and to restrain the vehicle under environmental conditions defined in paragraph 3.2.5.1 shall be demonstrated.

4.2.5.1.2 Erection. TBD

4.2.5.1.3 Transport to launch facility. The capability of the mated orbiter and booster to be transported shall be demonstrated. This operation will also demonstrate the validity of the procedures, equipment and facilities required to accomplish this transportation task with the shuttle.

4.2.5.1.4 Propellant loading. TBD

4.2.5.1.5 Serviceables loading. TBD

4.2.5.1.6 Stand by operations. TBD

4.2.5.1.7 Launch operations. The support equipment, procedures and facilities necessary to accomplish the following operations at the launch site shall be demonstrated (not necessarily in the order listed):

a. Perform launch readiness checks on the booster vehicle (3.2.1.6).

b. Place the booster vehicle on standby status (3.2.1.6)

c. Prepare the booster vehicle for launch within two hours from a standby status and demonstrate launch capability within a 60 second launch window for all launch azimuths (3.2.1.6).

d. Load propellants (3.2.1.6).

e. Load crew (3.2.2.5.3).

f. Booster rocket engine ignition (3.2.1.6).

g. Shuttle vehicle launch release (3.2.1.6).

4.2.5.2 Mission operations. The operations necessary to show compliance with the Section 3 requirements for all activities from booster vehicle liftoff through landing runout will be demonstrated by the test requirements in the following paragraphs. The design reference mission will be the basis for the sequence and designation of the functions performed.

4.2.5.2.1 Liftoff and boost operations. The capability of the booster vehicle system to perform the following functions shall be demonstrated (not necessarily in the order listed):

a. To boost orbiter as specified in paragraph 3.2.1.1.1 while manned by a pilot and copilot, the operation of the booster by one crew member from either seat shall be demonstrated as required by 3.2.2.5.3.

b. To maintain shuttle vehicle attitude and acceleration in accordance with the design reference mission profile based on commands by the on-board guidance and navigation system, paragraph 3.7.8.2.

c. To separate the orbiter and booster as specified in 3.2.1.1.2 including shutdown of the booster rocket engines, paragraph 3.7.1.2

d. To maintain a shirtsleeve environment for the crew, paragraph 3.7.15.2.

e. To receive and transmit both voice and data, paragraph 3.7.11.2.

4.2.5.2.2 Post-staging operations. The post-staging requirements of the booster shall be demonstrated as follows:

a. The booster shall reenter the earth's atmosphere as specified in paragraph 3.2.1.1.3.

b. After attaining cruise attitude, the booster shall cruise under its own power as specified in 3.2.1.1.4, 3.2.1.1.5 and 3.2.1.1.6.

c. The booster shall demonstrate its capability to land horizontally, paragraph 3.2.1.1.7.

d. The use of both atmospheric and non-atmospheric controls as specified in 3.7.10.2 shall be demonstrated.

4.2.5.2.3 Inspection, maintenance, and repair operations. Completion of the postflight test operations listed below is intended to demonstrate this capability (not necessarily in the order listed):

a. Taxi or tow of the booster to a safing area, paragraph 3.2.1.4.

b. Safing the booster. Partial safing shall be accomplished by on-board safing equipment (3.2.1.7). Final safing shall be completed by air transportable equipment, paragraph 3.2.2.5.5.

c. Crew egress from the booster, paragraph 3.2.2.5.3.

d. Perform maintenance, refurbishment, and checkout as required. Demonstrate the capability to perform these operations as specified in paragraph 3.2.4.1.

e. Prepare the booster vehicles for storage, paragraph 3.2.2.7.

4.2.5.2.4 Transport/ferry flight elements to the maintenance and refurbishment facility. TBD

4.2.5.2.5 Abort operations. TBD

5 PREPARATION FOR DELIVERY

5.1 Preservation, packaging, and packing. Preservation, packaging, and packing requirements shall be in accordance with standards and specifications listed in Technical Specifications Listing MSFC-TSL-488, Department of Defense Index to Federal and Military Specifications and Standards, National Aerospace Standards, Packaging Index NAS 851, and Convair Aerospace Handling and Packaging Index Report 4833A60.

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6 NOTES

6.1 Intended use. The intended use of this CEI is to boost an orbiter vehicle out of most of the earth's atmosphere, give it an initial volocity, release it, and then allow the CEI to return into the atmosphere intact. Following return to the atmosphere, the CEI is intended to provide its own propulsion to fly to a satisfactory landing site in such condition that it can be readily refurbished and readied for subsequent mission flights at a lower total cost than if the CEI were not recovered.

6.2 Reserved

6.3 Definitions

6.3.1 Weight definitions. Unless otherwise specified herein, the weight definitions of MIL-STD-254 will apply.

6.3.1.1 Dry weight. Dry weight is the weight of all of the subsystems excluding crew, propellants, payload and operational fluids and gases.

6.3.1.2 Booster gross weight. The booster gross weight is the summation of dry weight empty plus useful load propellants and operational fluids gases, and crew.

6.3.2 Flight definitions

Term	Definition	Units
Time	Time from 2 inch motion of vehicle	seconds
Attitude	Geocentric attitude measured using the geometric position vector from the reference ellipsoid	nautical miles or feet as specified
Range	Surface range from launch pad	nautical miles
Inertial Velocity	Velocity with respect to the inertial coordinate system	ft/sec
Relative Velocity	Velocity magnitude with respect to the rotating earth coordinate system	ft/sec
Relative Flight Path Angle	Angle between relative velocity vector and the local horizontal plane, measured positive above and negative below the plane. The horizontal plane is defined as a plane normal to the geocentric position vector.	degrees
Axial Load Factor	Thrust minus drag divided by vehicle g's weight $\frac{T-D}{W}$.	none

6.3.3 Ascent. Ascent begins with the release of holddown links. Links are released after the vehicle has traveled 2 inches vertically from the pad.

6.3.4 Staging. Staging sequence begins when the signal is initiated by the main propulsion system (propellant depletion sensors) to start the physical act. It ends two seconds after the physical disconnect occurs.

6.3.5 Intent of qualification testing. The intent of qualification testing is defined in the test plan and in SS613M0001.

6.3.6 Qualification. The definition of qualification is stated in the test plan and in SS613M0001.

6.3.7 Test and evaluation. The definitions of test and evaluation is stated in the test plan and in SS613M0001.

6.3.8 Major malfunction. A major malfunction is a failure situation from which continued safe mated flight to booster propellant depletion is not possible.

APPENDIX 10

Appendix 10 is reserved to specify the flight test articles that may be used in the Space Shuttle Program as delineated in the Preliminary Test Plan. The appendix will be used to enumerate the differences between the test articles and the operational booster. An example of such differences is to be found in flight test instrumentation.

APPENDIX 20

20.1 SCOPE

This appendix specifies the test methods planned to verify the requirements stated in Section 3 of the Booster CEI Specification.

20.2 TABLE

The verification table is constructed so that the characteristics to be verified are arranged in the order of their appearance in the specification. Since many of the requirements have been expressed by reference to another document, the table indicates the specification and, where possible, the specific paragraph of that document that indicates the characteristic to be verified. The table also indicates the specific test method, if appropriate, that can be used to verify the requirement. Finally the table indicates whether the characteristic is intended to be verified by engineering testing, formally qualified, specifically verified in reliability testing or tested as a critical component of the CEI.

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3	X								
3.1	X								
3.1.1	X								
3.1.2									
3.1.2.1		3	5	N/A	5	5	5		
3.1.3		3							
3.1.4		3		4					
3.1.5			5	4					
3.2	X								
3.2.1		3	5	N/A					
3.2.1.1		3	5	N/A					
3.2.1.1.1		3	5	N/A					4.2.5.2.1
3.2.1.1.1.1		3	5	N/A			5		4.2.5.3
3.2.1.1.1.1.1		3	5	N/A			5		
3.2.1.1.1.1.2		3	5	N/A			5		
3.2.1.1.1.1.3		3	5	N/A					
3.2.1.1.2		3	5	N/A					4.2.5.2.1
3.2.1.1.2.1		3	5	N/A			5		
3.2.1.1.2.1.1		3	5	N/A			5		
3.2.1.1.2.1.2		3	5	N/A			5		
3.2.1.1.2.1.3		3	5	N/A			5		
3.2.1.1.3		3	5	N/A			5		4.2.5.2.2
3.2.1.1.3.1		3	5	N/A			5		
3.2.1.1.3.1.1		3	3	3			5		
3.2.1.1.3.1.2		3	5	N/A					
3.2.1.1.3.1.3		3					5		
3.2.1.1.4		3	5	N/A			3,5		4.2.5.2.2, 4.2.5.2.3

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.1.4.1		3	5	4			5		
3.2.1.1.5		3		5			5		4.2.5.2.2
3.2.1.1.5.1		3		5					
3.2.1.1.6		3		5			5		4.2.5.2.2
3.2.1.1.6.1		3		5					
3.2.1.1.7		3		5			5		4.2.5.2.2
3.2.1.1.7.1									
3.2.1.1.7.2		3	5	N/A					
3.2.1.1.8		3	5	N/A			5		4.2.5.1
3.2.1.1.8.1		3	5	N/A					
3.2.1.2		3					5		
3.2.1.2.1		3							
3.2.1.2.1.1		3							
3.2.1.2.2		3		5					
3.2.1.2.2.1		3		5					
3.2.1.2.3		3							
3.2.1.3		3					5		
3.2.1.3.1				5					
3.2.1.3.2		3							
3.2.1.3.2.1	X		5	N/A			1		
3.2.1.3.2.2		3	1	N/A		1			4.2.5.1
3.2.1.4		3	4	N/A				5	4.2.5.2.3
3.2.1.5		3	3	4		1	1		4.2.5.1
3.2.1.5.1		3	3						
3.2.1.6		3	4	4	5	5			4.2.5.1.7
3.2.1.7	X		4	4		5			4.2.5.2.3
3.2.1.8			1	1				5	4.2.5.1

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.1.9								5	4.2.5.1
3.2.2				4					
3.2.2.1				4					
3.2.2.2		3							
3.2.2.3		3	3	3					
3.2.2.4			1		1		3		
3.2.2.4.1			1				3	1	
3.2.2.4.2		3					3	5	
3.2.2.4.3		3					3	5	
3.2.2.4.4		3					3		
3.2.2.4.5		3					3		
3.2.2.4.6		3					3		
3.2.2.5									
3.2.2.5.1									
3.2.2.5.2			3						4.2.5.2.3
3.2.2.5.3						5			4.2.5.1.7
3.2.2.5.4			3						4.2.5.2.1
3.2.2.5.5				1					4.2.5.2.3
3.2.2.5.5.1								5	
3.2.2.5.6			3						
3.2.2.6								5	
3.2.2.7								5	4.2.5.2.3
3.2.2.8		3				5			
3.2.2.8.1		3							
3.2.2.8.2									
3.2.2.8.3									
3.2.2.9									

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.2.3									
3.2.3.1				1					
3.2.3.2		3							
3.2.3.3	X								
3.2.4									
3.2.4.1				4					4.2.5.2.3
3.2.4.1.1								5	
3.2.4.1.2								5	
3.2.4.1.3				5	1				
3.2.4.2			3						
3.2.4.3									
3.2.4.4	X								
3.2.4.5	X								
3.2.4.5.1				4					
3.2.5	X								
3.2.5.1	X								
3.2.5.2							5		
3.2.5.2.1							5		
3.2.6				4,5					
3.3	X								
3.3.1		3	1						
3.3.1.1		3		4	4				
3.3.2			1	1			5		
3.3.3			4	4					
3.3.3.1			4						
3.3.4			4	4					

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.3.5				4					
3.3.6		3		1	4				
3.3.7		3							
3.3.8	X								
3.3.8.1		3							
3.3.8.2		3							
3.3.8.3		3							
3.3.8.4		3							
3.3.8.5		3							
3.3.8.5.1				5					
3.3.8.5.2				5					
3.3.8.5.3				5					
3.3.8.6				4					
3.3.8.7		3							
3.3.8.8		3		4					
3.3.8.9		3							
3.3.8.10									
3.3.8.11				1	4				
3.3.8.12									
3.3.8.13				5					
3.4	X								
3.4.1	X								
3.5			3	3					
3.5.1		3		3					
3.5.1.1				3					
3.5.1.2				3					
3.5.1.3				3					

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.5.2				4					
3.5.3				4					
3.6			3	5					
3.6.1									
3.6.1.1									
3.6.1.1.1									
3.6.1.1.2									
3.6.1.2									
3.6.1.3				4					
3.6.2									
3.6.2.1									
3.7	X								
3.7.1									
3.7.1.1									
3.7.1.2				3					4.2.5.2.1
3.7.1.2.1	X								
3.7.1.2.2		3							
3.7.1.2.3		3				5			
3.7.1.2.4		3		1				1	
3.7.1.2.5		3							
3.7.1.2.6		3							
3.7.1.2.7		3							
3.7.1.2.8		3					5		
3.7.1.2.8.1		3					5		
3.7.1.2.8.2		3					5		
3.7.1.3				4					
3.7.1.3.1				4					
3.7.1.3.2				4					

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.2									
3.7.2.1		3		1,4					
3.7.2.2							5		
3.7.2.2.1	X								
3.7.2.2.2	X							1	
3.7.2.2.3		3		1					
3.7.2.2.4		3							
3.7.2.3				4					
3.7.3									
3.7.3.1				4					
3.7.3.2						5			
3.7.3.2.1	X								
3.7.3.2.2	X								
3.7.3.2.3							5		
3.7.3.3				4					
3.7.4									
3.7.4.1				4,5					
3.7.4.2									
3.7.4.2.1	X								
3.7.4.2.2			1	1				1	
3.7.4.2.3			1						
3.7.4.2.4			1						
3.7.4.2.5				1					
3.7.4.3				4					
3.7.5									
3.7.5.1				1,4					
3.7.5.2	X								

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.5.2.1	X								
3.7.5.2.2	X								
3.7.5.2.3							5		
3.7.5.2.4							5		
3.7.5.2.5							5		
3.7.5.3				4					
3.7.6			3		1,4				
3.7.6.1					1				
3.7.6.2	X								
3.7.6.2.1	X								
3.7.6.2.2			3		1		5		
3.7.6.2.3			3	1	1		5		
3.7.6.3			3		4				
3.7.7									
3.7.7.1				1,4					
3.7.7.2	X								
3.7.7.2.1	X								
3.7.7.2.2				4			5		
3.7.7.2.3							5		
3.7.7.2.4							5		
3.7.7.2.5							5		
3.7.7.2.6									
3.7.7.3				4					
3.7.8									
3.7.8.1	X								
3.7.8.1.1									4.2.5.2.1
3.7.8.2									

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.8.2.1	X								
3.7.8.2.2	X								
3.7.8.2.3				1			5		
3.7.8.2.4				1			5		
3.7.8.2.6							5		
3.7.8.2.7							5		
3.7.8.2.8							5		
3.7.8.2.9							5		
3.7.8.2.10							5		
3.7.8.2.11							5		
3.7.8.2.12							5		
3.7.8.2.13							5		
3.7.8.2.14							5		
3.7.8.2.15							5		
3.7.8.2.16							5		
3.7.8.2.17							5		
3.7.8.2.18							5		
3.7.8.2.19							5		
3.7.8.2.20							5		
3.7.8.2.20.1							5		
3.7.8.2.20.2							5		
3.7.8.2.20.3							5		
3.7.8.2.21							5		
3.7.9					1				
3.7.9.1					1,4				
3.7.9.1.1					1				
3.7.9.1.2					1				

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.9.2	X								
3.7.9.2.1	X						5		
3.7.9.2.2.1							5		
3.7.9.2.2.2							5		
3.7.9.2.2.3							5		
3.7.9.2.2.4							5		
3.7.9.2.3							5		
3.7.9.2.3.1							5		
3.7.9.2.4							5		
3.7.9.2.4.1							5		
3.7.9.2.4.2							5		
3.7.9.2.5							5		
3.7.9.2.5.1							5		
3.7.9.2.6							5		
2.7.9.2.7							5		
3.7.10					1		5		
3.7.10.1							5		4.2.5.2.2
3.7.10.2	X						5		
3.7.10.2.1	X						5		
3.7.10.2.2							5		
3.7.10.2.3							5		
3.7.10.2.4							5		
3.7.10.2.5							5		
3.7.10.2.6							5		
3.7.10.3									
3.7.10.3.1									

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.10.3.2			4	4					
3.7.10.3.3			4	4					
3.7.10.3.4			4	4					
3.7.11	X				1				
3.7.11.1				1,4			5		
3.7.11.1.1				1					
3.7.11.2	X								
3.7.11.2.1	X						5		4.2.5.2.1
3.7.11.2.2							5		
3.7.11.2.3							5		
3.7.11.2.4							5		
3.7.11.2.5							5		
3.7.11.2.6							5		
3.7.11.2.7							5		
3.7.12					1				
3.7.12.1									
3.7.12.2	X								
3.7.12.2.1	X								
3.7.12.2.2							5		
3.7.12.2.3	X								
3.7.12.2.4							5		
3.7.12.3									
3.7.12.3.1									
3.7.13	X			4					
3.7.13.1				1,4					
3.7.13.2	X								

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.13.2.1	X								
3.7.13.2.2			1				5		
3.7.13.2.3			1				5		
3.7.13.2.4	X								
3.7.13.2.5								5	
3.7.13.2.6							5		
3.7.13.3				4					
3.7.13.3.1		3		4					
3.7.13.3.2		3		4					
3.7.13.3.3		3		4					
3.7.13.3.4				1					
3.7.14	X				1				
3.7.14.1				4					
3.7.14.1.1				1					
4.7.14.1.1.1				1					
3.7.14.1.1.2				1					
3.7.14.1.2							5		
3.7.14.1.2.1				1					
3.7.14.1.2.2				1					
3.7.14.1.2.3				1					
3.7.14.1.2.4				1					
3.7.14.1.3				4					
3.7.14.2	X						5		
3.7.14.2.1	X						5		
3.7.14.2.2							5		
3.7.14.2.2.1				1			5		

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.14.2.2.2				1			5		
3.7.14.2.3				1			5		
3.7.14.3				4					
3.7.14.3.1				4					
3.7.14.3.1.1				4					
3.7.14.3.1.2				4					
3.7.14.3.2				4					
3.7.15	X								
3.7.15.1	X								
3.7.15.2									
3.7.15.2.1	X								4.2.5.2.4
3.7.15.2.2							5		
3.7.15.2.3							5		
3.7.15.2.4							5		
3.7.15.2.5							5		
3.7.15.2.6							5		
3.7.15.2.7				1			5		
3.7.15.2.8				1			5		
3.7.15.2.9							5		
3.7.15.2.10							5		
3.7.15.2.11							5		
3.7.15.2.12							5		
3.7.15.2.13							5		
3.7.15.3				4					
3.7.15.3.1				4					
3.7.16	X								
3.7.16.1				4					

VERIFICATION CROSS REFERENCE INDEX

REQUIREMENTS FOR VERIFICATION

VERIFICATION METHOD:
1. Test
2. Similarity
3. Analysis
4. Inspection
5. Demonstration

N/A - Not Applicable

VERIFICATION PHASE:
A. Development
B. Qualification
C. Acceptance
D. Integrated Systems
E. Prelaunch Checkout
F. Flight/Mission Operations
G. Postflight

Section 3.0 Performance/ Design Requirement Reference	Verification Methods								Section 4.0 Verification Requirement Reference
	N/A	A	B	C	D	E	F	G	
3.7.16.2	X								
3.7.16.2.1	X								
3.7.16.2.2									
3.7.16.2.3									
3.7.16.2.4									
3.7.16.2.5									
3.7.16.2.6									
3.7.16.3				4					
3.8	X								
3.8.1	X								
3.8.2	X								